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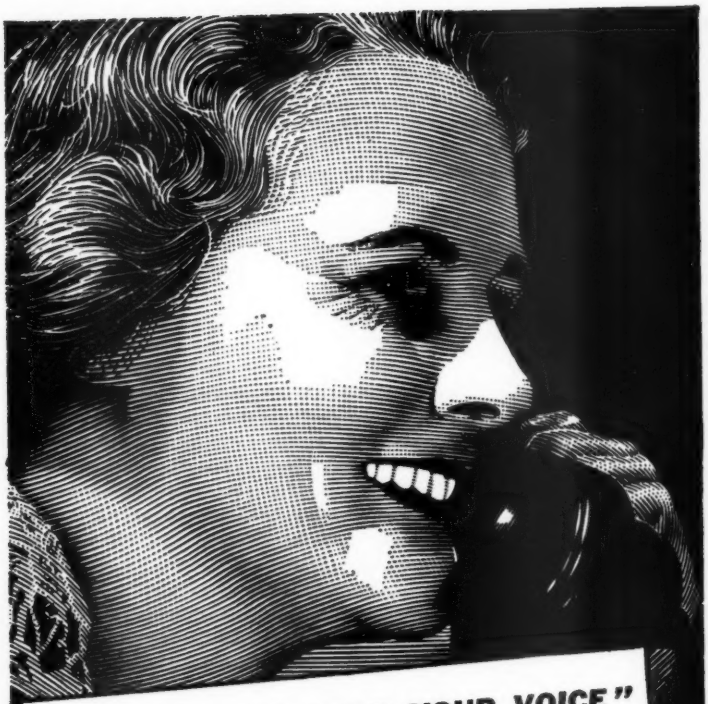

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DISTRIBUTION OF ANNUAL CONVENTIONS

By C. C. WILLIAMS, *Chairman of Committee*

Heretofore, selecting the place for holding the annual convention of the Society has been by vote of the Council upon the presentation of invitations and arguments by representatives of institutions which offered to be hosts. While the decisions have not generally been criticized, a desire has been expressed frequently for a more rational and systematic procedure in arriving at the choice. With a view to improvement, the Committee on Relations with Other Engineering Societies, to which the duty of making recommendation has been assigned, has made a study of conditions and proposes a formula for general guidance in allocating the annual convention to different regions. It is the thought of the committee that this formula, if approved by the Council as a general guide, would apportion the conventions on a rational basis, and would be departed from only when circumstances might arise which, in the judgment of the Council, seem to warrant the exception.

The formula is predicated on the two factors which seem to be primary considerations, namely (1) the function of the Society in the advancement of engineering education affected by the circulation of the convention over the area of its constituency, and (2) the convenience of the members in attending the convention. These factors are measured by the number of schools of engineering that are institutional members of the Society, the number prepared to entertain the convention, and the number of individual members in the respective areas. The average size of a local Section of the Society is about 100, hence, counting the membership by hundreds, gives this factor a weight somewhat commensurate with demonstrated convenience of assembly.

The derivation of the formula is as follows:

I. Divide the territory of S. P. E. E. into six zones, as follows:

Zone 1. *The East* (E). East of Allegheny Mountains (78° Long.), north of the Ohio River and the Mason and Dixon Line.

Zone 2. *The Midwest* (M). West of Alleghenies, east of Missouri-Red Rivers, north of Ohio River.

Zone 3. *The South* (S). South of Ohio—Mason and Dixon Line, and east of Mississippi River.

Zone 4. *The Near West* (N). West of the Mississippi-Missouri-Red rivers and east of the Rocky Mountains (106° Long.).

Zone 5. *The West* (W). West of the Rocky Mountains.
Zone 6. *Canada,* etc. (C). Canada and schools outside continental U. S. A.

II. Base the distribution of conventions upon three factors:

(*a*) Number of schools (institutional members) in the zone.
(*b*) Number of schools equipped for entertaining the convention.
(*c*) Membership in the zone.

The following data are approximate:

	Zone 1 *East* E	Zone 2 *Midwest* M	Zone 3 *South* S	Zone 4 *Near West* N	Zone 5 *West* W	Zone 6 *Canada,* etc. C
Schools	34	25	21	21	9	10
Available	12	14	11	12	10	6
Members (100's)	9.0	7.0	3.5	3.2	2.3	.6

Giving equal weights to these factors, the formula for distribution is

$6\,E + 6\,M + 3\,S + 3\,N + 2\,W + 1\,C =$ a cycle of 21 conventions.

Past meetings have been distributed as follows:

$18\,E + 18\,M + 5\,S + 2\,N + 1\,W + 2\,C = 46$ conventions.

III. Beginning to count in 1930 when the convention was last held outside continental U. S. A., and when the present membership status was practically attained, and distribution has been, including two conventions now fixed,

$3\,E + 3\,M + 1\,S + 1\,N + 1\,W + 1\,C = 10$ conventions, leaving for the future,
$3\,E + 3\,M + 2\,S + 2\,N + 1\,W + 0\,C = 11$ conventions to complete the current cycle.

Specific location could be correlated to conventions of other societies by allocation within the formula.

The zone boundaries perhaps might be set with greater particularity, but the generalized delimitation is more easily remembered. In the two cases where zone boundaries do not coincide with section boundaries, no division of interests need arise. If found desirable, these three schools could be attached to the other zones by

exception to the generalized boundaries, since they lie almost on the boundary in each case.

The formula is in close accord with past practice. It would indicate that normally in 1949, the convention might be expected to go outside continental United States and that at present the half cycle has been distributed approximately in accord with the proposed plan.

Comments by members will be received by the Secretary of the Society and referred to the Committee for consideration.

WHAT DEPARTMENTS TEACH MECHANICS?*†

By H. J. GILKEY,
Professor and Head

AND FRANK E. LIGHTBURN,
Assistant Professor

Department of T. & A. M., Iowa State College

The data on mechanics presented in this paper were obtained from a catalog study of the U. S. institutions listed in the JOURNAL OF ENGINEERING EDUCATION for December 1936 (Vol. XXVII, No. 4), pp. 368–373. To tabulate the information has not been simple, and a much longer and more vehement paper than this one could be written upon the need for some degree of uniformity in catalog practice in this country. Some catalogs seem designed more to conceal than to divulge specific information and the authors were not always successful in their attempt to uncover all of the essential facts. Invariably the more a catalog succeeded in confusing and concealing, the more volubly did it extoll the virtues of an engineering education as a medium for developing conciseness and adequacy of expression.

Even with the basic information available, its presentation is not a simple matter because of the wide range of auspices under which mechanics is taught and because of the variable scope of what is considered to be mechanics.

Mechanics is taught in departments of mechanics, civil engineering, mechanical engineering, mathematics, physics, and others. Besides the commonly accepted courses in statics, dynamics, strength of materials, testing materials laboratory, properties of materials, hydraulics, and hydraulics laboratory, some mechanics departments teach or administer such additional work as drawing, mathematics, engineering problems, graphic statics, concrete (plain and reinforced), highways, structures, metallography, building construction, thermodynamics, machine design, aero dynamics and mechanisms.

* Presented before the Mechanics Division S. P. E. E. at Cambridge, Mass., June 28, 1937.

† This study is the outgrowth of a question raised several months ago in a conversation with Professor Dan H. Pletta of Virginia Polytechnic Institute.

The table is an attempt to present a picture of both the allocation and the quantity of the mechanics taught in the colleges of this country. From what has just been said, it is apparent that such a presentation involves some approximation, some generalization and considerable arbitrary definition.

For convenience of reference both the columns and the colleges are numbered serially. Reading across the top of the table the columns may be explained as follows:

Column 1. Serial number of institution.

Column 2. Name and location of the institution.

Column 3. Day enrollment in engineering for 1936–7 as given in the JOURNAL for December 1936 (Vol. XXVII, No. 4), pp. 368–373. Enrollment figures in parentheses are taken from a recent catalog.

Column 4. Approximate number of engineering curricula offered. This does not include options offered under a given curriculum.

Column 5. Unit of division of the academic year; usually semester or quarter, S or Q.

Columns 6 to 10. Department in which mechanics courses are taught. The courses are indicated by the letters "abcdefg" as defined just above the table. Obviously the courses represented by these letters define the scope of mechanics as arbitrarily delimited in this paper.

Course "e," properties of engineering materials, requires some additional explanation because of the wide range in scope and allocation. In this paper the course is visualized as a 1 or 2 semester-hour treatment of the properties of materials as set forth in such a text as Moore or Mills. Some institutions list no such separate course but cover the subject of materials as a part of either Strength of Materials "c" or Materials Testing Laboratory "d." Others include in the course special work on highway materials or on plain concrete. Where the differences were apparent from the catalog they were covered by footnotes, but there were a number of other cases where complete information was not obtainable from the catalog. Where course "e" carries a credit in excess of 2 there is reason to suspect that its scope exceeds that intended to be included among the mechanics courses studied here.

The departmental subdivisions are explained as follows:

Column 6. Mechanics. As here listed a mechanics department is arbitrarily defined as a subdivision of the engineering faculty to which is definitely assigned one or more staff members who devote full time to the teaching of mechanics. Some schools have a skeleton organization to which one or more faculty members

are definitely assigned, but in which a majority of the mechanics teachers are borrowed from other departments.

Column 7. M.E. Mechanical Engineering department teaches the courses in this column. It is possible that some of the smaller schools listed under this heading should have been under Engineering (9).

Column 8. C. E. Civil Engineering department teaches the courses in this column. It is possible that some of the smaller schools listed under this heading should have been under Engineering (9).

Column 9. Engineering. Found in this group are engineering schools which are not subdivided into departments, presumably because their staff is too small to justify this overhead; schools which teach all common background courses in one department, called, perhaps, General Engineering; and schools that have a heading in their catalog called mechanics which, however, is taught by instructors from several other departments.

Frequently this type of handling closely resembles the skeleton departmental organization mentioned under Mechanics (6).

Column 10. Other. In this column are courses taught mostly under non-engineering auspices, usually in departments of mathematics or physics. The courses most frequently handled in this way are statics and dynamics (a and b). This arrangement is the one generally adopted by institutions, essentially non-engineering, which desire to show offerings in engineering. In two of the schools listed under Mechanics (6) the name of the department is Mathematics and Mechanics. The degree of resemblance between these and the ones listed under "Other" (10) depends of course upon the extent to which the conventional liberal arts mathematics point of view is dominant over the applied or engineering mechanics point of view.

Columns 11 to 17. Equivalent of semester hours required. These columns indicate for each of the seven subjects the credit hours required for the majority of the curricula. The footnote references supply additional explanations for the more important deviations and individual differences. Quarter hours have been converted to semester hours on the basis of 3 quarter hours equals 2 semester hours.

Abbreviations and Notes

Below are listed the abbreviations and notes which apply to material in the table.

[1] Letters in italics are special courses for certain curricula.

[2] Also other special courses for certain curricula.

[3] Includes some laboratory or computation periods additional to recitations.

[4] Includes concrete and road materials testing.

[5] Separate hydraulics department closely allied to that under which it is listed.

[6] Coöperative plan.

[7] In addition to courses listed a course of 7–9 sem.-hr. over "abcf" is given.

[8] The courses listed are for C.E.'s only. The M.E.'s and Ch.E.'s get their mechanics from a number of courses given in the physics and M.E. departments.

[9] Some included in other courses.

[10] Includes some mathematics.

[11] Includes laboratory work other than hydraulics and materials testing.

In columns 11 to 17 a dotted line from one box to another means that that course is combined with each succeeding course through which the line passes.

Summary of Information from the Table by Columns

Column 3. Day engineering enrollments vary between 39 and 3030 students. In comparing engineering schools on the basis of enrollments one must recognize that lines of cleavage differ. In some schools architecture, architectural engineering, chemical engineering and/or other curricula are administered under non-engineering auspices which means that mere numbers should not be taken too literally as an indication of relative engineering size.

Column 4. The numbers of engineering curricula offered vary between 1 and 16.

Column 5. 99 schools operate on the semester plan, 26 on the quarter, 6 coöperatively, one on both systems, and one with no apparent subdivision of the college year. Those on the coöperative plan have alternate periods in college and industry which periods vary for different schools.

Columns 6 to 10. Below are listed the numbers of institutions which teach virtually all * the primary courses in mechanics under the auspices indicated.

Dept. of Mechanics	32
Civil Engineering	34
Mechanical Engineering	14
Engineering	23
Other (Physics or Mathematics)	3
Distributed	27
	133

Of the distributed group 15 teach half of the primary mechanics courses in departments of physics or mathematics and in 6 of them the primary courses are equally divided between the Civil and Mechanical Engineering Departments.

While 35 schools have separate departments of mechanics, in 3 of these only two of the four primary courses are taught in the mechanics department.

* By "virtually all" is meant at least 3 of the 4 primary courses which arbitrarily are taken to be: statics, dynamics, strength of materials and hydraulics.

The teaching of primary courses in mechanics among the schools with the largest engineering enrollments is allocated as follows:

1. Purdue	3030 students	Dept. of Mechanics
2. Texas A. & M.	1993 students	C.E. and M.E.
3. Univ. Illinois	1889 students	Dept. of Mechanics
4. M. I. T.	1792 students	M.E.
5. Ohio State Univ.	1737 students	Dept. of Mechanics
6. Univ. Michigan	1683 students	Dept. of Mechanics
7. Ga. Inst. Tech.	1646 students	Dept. of Mechanics
8. Univ. Calif.	1412 students	C.E. and M.E.
9. Univ. Wash. (Seattle)	1370 students	C.E.
10. Iowa State College	1331 students	Dept. of Mechanics
11. Penn. State College	1308 students	Dept. of Mechanics
12. Univ. Texas	1221 students	C.E.
13. New York, City College	(1213)* students	C.E. and Physics
14. New York University	— * students	Dept. of Mechanics
15. Univ. Minnesota	— * students	Dept. of Mechanics
16. Univ. Wisconsin	— * students	Dept. of Mechanics

Thus for the 16 institutions with engineering enrollments over 1200,

10 have separate departments of mechanics,
2 teach mechanics in Civil Engineering,
1 teaches mechanics in Mechanical Engineering,
2 divide the mechanics between C.E. and M.E., and
1 divides the mechanics between C.E. and Physics.

Of about 25 schools with enrollments between 600 and 1200 half have separate departments of mechanics, leaving only a dozen mechanics departments for the 90 or so smaller schools.

Of the 23 schools classified as teaching their primary mechanics under "Engineering" (column 9):

11 have enrollments below 200.
None has an enrollment over 500.

Of the 18 schools classified as teaching 2 or more of the primary courses under "Other" (column 10) only 2 have enrollments above 500.

Thus it is the smallest enrollment group that teaches its mechanics under the auspices represented by columns 9 and 10.

Names of Mechanics Departments

Among the 35 departments of mechanics in this country 10 different names are used as follows:

15 Dept. of Mechanics,
6 Dept. of Engineering Mechanics,
5 Dept. of Applied Mechanics,

* Probably belong in this group. Enrollments not given.

2 Dept. of Theoretical and Applied Mechanics,
2 Dept. of Mathematics and Mechanics,
1 Dept. of Mechanics and Hydraulics,
1 Dept. of Mechanics and Materials,
1 Dept. of Mechanics and Structures,
1 Dept. of Mechanics and Materials of Construction,
1 Dept. of Engineering Drawing and Mechanics.

Summary of Courses Taught

Of the 35 mechanics departments:

16 teach all of the major subjects (abcf).
17 include hydraulics (f).
9 include hydraulics laboratory (g).
31 include statics, dynamics and strength of materials (abc) with or without additional courses.
3 include only statics and dynamics (ab).
1 includes statics, dynamics and hydraulics (abf).
6 teach all of the courses treated in this paper as mechanics (abcdefg).
23 teach materials testing laboratory (d).
12 include properties of materials (e).

Closing Remarks

This survey shows that the majority of the largest schools have separate departments of mechanics, although there are notable exceptions. As might logically be expected schools of intermediate size are more divided in practice; while the small schools either teach the mechanics as non-departmentalized engineering or else farm it out to such non-engineering departments as mathematics and physics. It is not the function of this paper to attempt an appraisal of the different methods of allocating the mechanics work. Either good or poor mechanics can be taught under any of the set-ups outlined.

The study has emphasized the need for more uniformity and greater clarity of statement in college catalogs. Some of the confusion encountered here probably arises from the desire of institutions which are inadequately staffed, for the proper handling of engineering work, to cover up their deficiencies. The E.C.P.D. accrediting program will doubtless correct or eliminate some of these. It may also prove beneficial in getting some of the overly individualistic institutions to recognize that the oldest ways of doing things are not necessarily the best. While standardization can, perhaps, be overdone, that situation has not yet arrived either in the handling of mechanics or in the formulation of college catalogs.

A Compilation of Catalogue Data on Mechanics

a, Stat.; b, Dyn.; c, Str. of Mat.; d, M. T. Lab.; e, Prop. of Mat.; f, Hyd.; g, Hyd. Lab.

	Name and Location	No. Engr.	No. Cur.	Sems. or Q.	Courses Taught in					Equiv. of Sem. Hr. Req'd						
					Mech.	M.E.	C.E.	Engr'g	Other	a	b	c	d	e	f	g
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	Akron U., Akron, O.	78	4	S		f	c		ab	3	---	6	—	—	3	—
2	Ala. Polytech., Auburn	583	8	S		abcef				5[2]	---	5[2]	—	2	3	—
3	Ala. U., University	616	8	S	abcdefg					5	---	5	2	2	2	1
4	Alaska U., Fairbanks	---	4	S			abcdefg			3[2]	---	3[2, 3]	—[3]	—[3]	3	---
5	Ariz. U., Tucson	293	4	S			cdefg		ab	6	---	3	1	2	3	1
6	Ark. U., Fayetteville	270	4	S		ab	cdefg			5[2]	---	5[2]	1[2]	1	3	1
7	Armour Inst., Chicago	838	7	S	abcf					3[2]	3[2]	5[2]	—	—	5	—
8	Brooklyn Poly., Brooklyn	472	4	S		d	cefg		ab	5	---	3	1	—[3]	3[2]	1
9	Brown U., Providence, R. I.	135	3	S				abcefg		6[2]	---	3[2]	—	3[2]	3	---
10	Bucknell U., Lewisburg, Pa.	171	4	S		ab	cdefg			4	---	4	3	---	4	---
11	Calif. U., Berkeley	1412	6	S		ab*g*	cdefg			6	---	5[2]	1[2]	2	3	---[2]
12	Calif. Tech., Pasadena	—	4	Q	abcd	ef[3]g[5]				6½[2]	---	3½[2]	½	2½	2½[2]	½
13	Calif. U. of So., L. A.	240	6	S Q				abcefg abc fg		6[2] 6	--- ---	5[2] 6	— —	3 —	3 4	--- ---
14	Carnegie T., Pittsburgh	995	6	S	abc		defg			3	3	3	2[2]	---	3[2]	---
15	Case, Cleveland, O.	727	5	S	abcd		*fg*			6[2]	---	3	½	—	—[2]	—[3]
16	Catholic U., Wash., D. C.	126	7	S				abcdfg		6	---	2	1	—	3	1
17	Cincinnati U., Cincinnati	1168	7	—[5]	abc	d*f*	*f*			5½	4	5½[2]	1½[2]	—	—[2]	—
18	Citadel, Charleston, S. C.	124	1	S			abcdf			3	---	3	4[4]	—	3	—

18	Citadel, Charleston, S. C.	124	1	S			abcdf			3--	---	3	4[4]	—	3	—

A Compilation of Catalogue Data on Mechanics—*Continued*

a, Stat.; b, Dyn.; c, Str. of Mat.; d, M. T. Lab.; e, Prop. of Mat.; f, Hyd.; g, Hyd. Lab.

	Name and Location	No. Engr.	No. Cur.	Sems. or Q.	Courses Taught in					Equiv. of Sem. Hr. Req'd						
					Mech.	M.E.	C.E.	Engr'g	Other	a	b	c	d	e	f	g
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
19	Clarkson, Potsdam, N. Y.	317	5	S	abcf	deg			*e*	6--	---	3	1	—[3]	3	1
20	Clemson Ag. C., Clemson, S. C.	593	5	S		abcefg	*acf*			3[2]	3	3[2]	—	—[3]	3[2]	½
21	Colo. Mines, Golden, Colo.	594	4	S	abf		c			5--	---	4[3]	—	—	with a	—
22	Colo. St. Coll., Ft. Collins	350	3	S			*cdfg*		ab	3--	---	5	—[3]	—	—[3]	—[3]
23	Colo. U., Boulder	634	5	Q			abcdef*g*		*ab*	2[2]	2[2]	3½	1½	—[3]	2	—[3]
24	Columbia, New York	413	8	S	ab	*g*	*cf*			3[2]	3[2]	4[2, 3]	—	—	—[3]	—[3]
25	Conn. St. Coll., Storrs	68	3	S				abcdef		3	3	3	1	2	2[2]	—
26	Cooper Union, New York	294	3	S			*abcd*fg		ab	6[2]	---	4[2]	2[2]	—	2[2]	--- ---
27	Cornell, Ithaca, N. Y.	915	5	S		abcd*ef*	*acdefg*			5[2]	---	4[2]	—[3]	—[3]	2[2]	—[3]
28	Dartmouth, Hanover, N. H.	93	1	S			abcdefg			5--	---	4	½	3	4	½
29	Dayton U., Dayton, O.	156	4	S			cdf		ab	6--	---	4	1	—	—[3]	—
30	Delaware U., Newark	175	4	S	abcd		fg			4	4[2]	6	1½	—	3	1½
31	Denver U., Denver	129	2	Q					abc	3½	3½	3½	—	—	—	—
32	Detroit U., Detroit	508	7	—[6]	abcd		f			3[2]	2	5[2]	½	—	3	—
33	Drexel, Phila., Pa.	743	4	—[6]		eg	abcdf			2½	2	2½	½[2]	1½	2	½
34	Duke U., Durham, N. C.	141	3	S				abcef		5--	---	4	—	—[3]	4	—
35	Florida U., Gainesville	378	6	S		abce	*dfg*			10[2]	------	---	—[2]	2	3	--- ---
36	Ga. Tech., Atlanta	1646	10	S	abc	dg	*ef*			6[2, 3]	---	5[2]	1[2]	—[3]	3	with d[2]
37	Geo. Wash. U., Wash., D. C.	392	3	S			abcdefg			2	3	3	2	4	4	with d

A COMPILATION OF CATALOGUE DATA ON MECHANICS—*Continued*

a, Stat.; b, Dyn.; c, Str. of Mat.; d, M. T. Lab.; e, Prop. of Mat.; f, Hyd.; g, Hyd. Lab.

	Name and Location	No. Engr.	No. Cur.	Sems. or Q.	Courses Taught in					Equiv. of Sem. Hr. Req'd						
					Mech.	M.E.	C.E.	Engr'g	Other	a	b	c	d	e	f	g
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
38	Gettysburg C., Gettys., Pa.	39	3	S				abcdef		6	---	7[3]	---	---	3	—
39	Howard U., Wash., D. C.	—	4	S		g	abcdef			3	3	3	2	2	3	1
40	Idaho U., Moscow	398	5	S			abcdfg			2	2	3	1[3]	—	3	---
41	Illinois U., Urbana	1889	13	S	abcdefg					2[3]	3	3[3]	1[3]	—[3]	2	1[3]
42	Iowa St. Coll., Ames	1331	9	Q	abcdefg					2	2½	3½	½[3]	1½	2½	---
43	Iowa U., Iowa City	370	6	S	abcdefg					4	---	4	2	---	2[3]	1
44	Johns Hopkins, Baltimore	—	5	S		abde	cfg			4	---	4	—[3]	3[3]	4[3]	---
45	Kans. St. Coll., Manhattan	877	8	S	abcdfg					4[3]	---	5[3]	1[3]	—	3	1
46	Kans. U., Lawrence	606	8	S	abcdfg					2	3	4[3]	1	—	3	1
47	Kentucky U., Lexington	429	6	S	abcef		d			4	---	4	½	with c	1[3]	—
48	Lafayette, Easton, Pa.	227	5	S		*abc*	abcdefg			5[3]	---	4[3]	2[3]	—[3]	3[3]	with d
49	Lehigh U., Bethlehem, Pa.	968	9	S		*b*	cdefg		ab	4	---[2]	3[3]	1	with c	3[3]	1
50	Lewis Inst., Chicago	—	3	Q		abc	defg			3½	3½	3½	5	---	5[3]	---
51	La. St. U., Baton Rouge	1059	7	S	abcde		*e*fg			5	---	4	½	with c[3]	3	½
52	Louisville, Louisville, Ky.	154	4	Q			abcdfg			3½	---	3½	½	—	2½	½
53	Maine U., Orono	364	6	S	abc	*deg*	f			10[3]	-----	---	—[3]	—[3]	2[3]	—[3]
54	Manhattan C., New York	217	3	S				abcdfg		4	3	3[3]	2	—	3	1
55	Marquette U., Milwaukee	464	4	—[6]				abcdef		3½	2	3½	1½	—[3]	2	—
56	Maryland[7] U., Coll. Park	303	3	S				abcdefg[7]		3[3]	---	4[2, 3]	2	---	3[3]	---

56	Maryland[7] U., Coll. Park.....	303	3	S				abcdefg[7]		3[3]	---	4[2, 3]	2	---	3[3]	---

A Compilation of Catalogue Data on Mechanics—*Continued*

a, Stat.; b, Dyn.; c, Str. of Mat.; d, M. T. Lab.; e, Prop. of Mat.; f, Hyd.; g, Hyd. Lab.

	Name and Location	No. Engr.	No. Cur.	Sems. or Q.	Courses Taught in					Equiv. of Sem. Hr. Req'd						
					Mech.	M.E.	C.E.	Engr'g	Other	a	b	c	d	e	f	g
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
57	Mass. Inst. T., Cambridge.....	1792	14	S		abcde*g*	*f*			6[2]	---	3[2]	$\frac{3}{4}$[2]	with c[2]	2[2]	—[2]
58	Mich. C. Min. & T., Houghton....	(510)	7	Q		cde	f		ab	4$\frac{1}{2}$	---	4[2]	—[2]	4.4	2$\frac{1}{2}$[2]	—
59	Mich. St. C., E. Lansing.....	376	4	Q		de	abc*fg*			3$\frac{1}{2}$	3$\frac{1}{2}$	3$\frac{1}{2}$	$\frac{1}{2}$	1$\frac{1}{2}$	—[2]	—[2]
60	Mich. U., Ann Arbor.....	1683	10	S	abcdf					3	3	4	1[2]	—	3	—
61	Minnesota U., Minneapolis.....	—	12	Q	abcdefg					3$\frac{1}{2}$[2]	3$\frac{1}{2}$[2]	3$\frac{1}{2}$[2]	1$\frac{1}{2}$[2]	with c	2$\frac{1}{2}$[2]	$\frac{1}{2}$
62	Missouri U., Columbia.....	368	5	S		b	acdef			2	3	4	3---	---	3	—
63	Mo. Sch. Min. & T., Rolla.....	473	7	S	abc*de*		fg			3[2]	---	3[2]	—[2]	—[2]	3	---
64	Montana St. C., Bozeman.....	377	7	Q			*df*	abc	e	2$\frac{1}{2}$[2]	2$\frac{1}{2}$[2]	2$\frac{1}{2}$[2]	—[2]	6	2$\frac{1}{2}$	—
65	Montana Mines, Butte.....	225	3	S				abcf		2---	---	4	—	—	2	—
66	Mississippi U., Oxford.....	56	3	S				abcdef		3	2	5	4[4]	1	3	—
67	Miss. St. C., Starkville.....	758	4	S		ab	*abcdefg*			6[2]	---	4[2, 3]	—[2]	—[2]	—[2]	—[2]
68	Nevada U., Reno.....	204	4	S			cdf		ab	5---	---	3	1	—	3	—
69	Nebraska U., Lincoln.....	755	6	S	abcd		f			4---	---	4	1	—	3[2]	—
70	Newark C. Eng., Newark, N. J....	639	4	S	ab	f*g*			cd	10[2, 3]	---	6[2]	1	—	3[2]	—[2]
71	New Hampshire U., Durham.....	319	5	Q		abcd	*efg*			6[2]	-----	---	1$\frac{1}{2}$	—[2]	3$\frac{1}{2}$[2]	—[2]
72	N. Mex. U., Albuquerque.....	154	4	S		be	cdefg	a		3[2]	3	3	2---	---[2]	3	1
73	N. Mex. A. & M., St. College.....	—	5	S		ab	cdef*g*			3	3	3	2---	---	3	—[2]
74	N. Mex. Sch. Mines, Socorro.....	143	5	S			abcf			4---	---	2	—	—	2	—
75	New York U., New York.....	—	5	S	abcdfg				e	3	3	2[2]	$\frac{1}{2}$	—[2]	3[2]	$\frac{1}{2}$

A COMPILATION OF CATALOGUE DATA ON MECHANICS—*Continued*

a, Stat.; b, Dyn.; c, Str. of Mat.; d, M. T. Lab.; e, Prop. of Mat.; f, Hyd.; g, Hyd. Lab.

	Name and Location	No. Engr.	No. Cur.	Sems. or Q.	Courses Taught in					Equiv. of Sem. Hr. Req'd						
					Mech.	M.E.	C.E.	Engr'g	Other	a	b	c	d	e	f	g
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
76	New York C. C., New York	(1213)	4	S			cdefg		ab	5	—	4^{2}	3	—	3	1
77	N. Car. St. Coll., Raleigh	826	8	Q		*c*	abc*def*			6	—	4^{2}	—[3]	—[3]	4^{2}	—
78	N. Car. U., Chapel Hill	70	4	Q				abcdefg		6	—	4^{2}	—	$5\frac{1}{2}$[2, 3]	$3\frac{1}{2}$	—
79	N. Dak. Ag. Coll., Fargo	257	8	Q				abcdef		$2\frac{1}{2}$[2]	$1\frac{1}{2}$[2]	4^{2}	$\frac{1}{2}$	2	4	—
80	N. Dak. U., Grand Forks	261	7	S			abcd*fg*			5	—	3	—[3]	—	2^{2}	—[2]
81	Northeastern U., Boston	—	5	—[6]		abc*d*	ef			$2\frac{1}{2}$	$2\frac{1}{2}$	$5\frac{1}{2}$[2]	—[3]	$1\frac{1}{2}$	2	—
82	Northwestern U., Evanston	—	4	S				abcfg		$\frac{1}{2}$[2]	—	6^{2}	—	—	3	—
83	Norwich U., Northfield, Vt.	114	2	S			abcdefg			3	3^{2}	3^{2}	2^{2}	—[3]	3	with d
84	Notre Dame, South Bend	408	7	S			abc*f*			4^{2}	—	4^{2}	—	—	—[3]	—
85	Ohio Northern, Ada	110	4	Q			cdf		ab	$3\frac{1}{2}$	—	$6\frac{1}{2}$	—[3]	—	$3\frac{1}{2}$	—
86	Ohio St. U., Columbus	1737	12	Q	abcdf	*eg*				$3\frac{1}{2}$[2]	2	$3\frac{1}{2}$	—	—[3]	2	—[9]
87	Okla. A. & M., Stillwater	898	8	S			abcdefg		e	3	2	5	—	$3^{2, 3}$	3	—
88	Okla. U., Norman	1103	13	S	abcd*ef*	*g*				4	—	4	1	—[3]	3	—[2]
89	Ore. St. Ag. C., Corvallis	760	5	Q		abcde	*abcfg*			$2^{2, 3}$	$2^{2, 3}$	$2^{2, 3}$	$1\frac{1}{2}$	—	2^{2}	—
90	Penn. St. C., State College	1308	16	S	abcde		$f^{2}g^{5}$			4^{2}	—	4^{2}	1	1	2^{2}	1
91	Penn. U., W. Phila. Towne Scientific[8] Moore Elec. Engr.	303 70	4 1	S S		 abcd	abcdefg[8] f		 e	2 3	3 —	4 —	1 —[9]	3 3	4 —[9]	1 —
92	Pittsburgh U., Pitts., Pa.	757	8	S		b	*abcfg*			4^{2}	2^{2}	3^{2}	—	—	2^{2}	—[2]
93	Puerto Rico U., Rio Piedras	251	4	S		g	abcdef			4	—	3	—[3]	with c[3]	3	1

93	Puerto Rico U., Rio Piedras.....	251	4	S		g	abcdef			4--	---	3	—[3]	with c[3]	3	1

A Compilation of Catalogue Data on Mechanics—*Continued*

a, Stat.; b, Dyn.; c, Str. of Mat.; d, M. T. Lab.; e, Prop. of Mat.; f, Hyd.; g, Hyd. Lab.

	Name and Location	No. Engr.	No. Cur.	Sems. or Q.	Courses Taught in					Equiv. of Sem. Hr. Req'd						
					Mech.	M.E.	C.E.	Engr'g	Other	a	b	c	d	e	f	g
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
94	Princeton, Princeton, N. J.....	254	5	S		fg	cde		ab	6--	---	4[3]	2---	---	3	---
95	Purdue, Lafayette, Ind.....	3030	6	S	abc		*defg*			8--	-----	---	$\frac{1}{2}$[3]	—[3]	3	—[3]
96	Rensselaer, Troy, N. Y.....	950			Data not obtainable from catalog											
97	R. I. St. Coll., Kingston.....	260	4	S		abcdef				5--	---	2	3---	---	3	—
98	Rice Inst., Houston, Tex.....	402	4	Yr.			cdefg		ab	12[10]	---	8[3]	---	-----	---	---
99	Rose Poly., Terre Haute.....	191	4	S		*b*	acdf		e	6	—[3]	with a	$\frac{1}{2}$	3	3	—
100	Rochester U., Rochester.....	135	2	S		abcdefg				6--	---	3	2[3]	2	3	with d[3]
101	Rutgers, New Bruns., N. J.....	186	3	S			fg	abcde		3	3	8	---	---	4	---
102	S. Dak. St. C., Brookings.....	—	4	Q			abcdef			8--	-----	---	—[3]	—[3]	2	—
103	S. Dak. S. Min., Rapid City.....	309	6	S			abcd*f*			3	—[3]	5	---	—	—[3]	—
104	Southern Meth., Dallas.....	158	4	—[6]			fg	abcd		5.3	---	3.6	1.1	—	3.6	1.1
105	Stanford U., Stanford.....	128	5	Q			abcdfg			6$\frac{1}{2}$	---	3$\frac{1}{2}$[3]	---	—	3$\frac{1}{2}$	---
106	Stevens, Hoboken, N. J.....	497	1	S	ab	cdfg				6--	---	7	2	—	with c	with d
107	Swarthmore, Swarth., Pa.....	59	3	S			abcf	de		4--	---	4	4---	---	4	—
108	Syracuse U., Syracuse, N. Y.....	376	5	S		cd	*cfg*		ab	6--	---	6[3]	1	—	3[3]	—[3]
109	Santa Clara U., S. C., Cal.....	60	3	S				abcdefg		8--	---	5	1	—[3]	5	---
110	Tennessee U., Knoxville.....	510	6	Q			abcdef[5]g[5]			2	2	4	2---	---	6[3]	---
111	Texas A. & M., Coll. Station.....	1993	9	S		ab	*cdfg*			3	3	4	—[3]	—	3	—[3]
112	Texas U., Austin.....	1221	8	S			*abcdefg*			3[3]	—[3]	3[3]	—[3]	—[3]	3	—[3]
113	Texas Tech., Lubbock.....	510	9	S			abcd*efg*			3[3]	3	3[3]	1[3]	—[3]	2	1

A COMPILATION OF CATALOGUE DATA ON MECHANICS—*Continued*

a, Stat.; b, Dyn.; c, Str. of Mat.; d, M. T. Lab.; e, Prop. of Mat.; f, Hyd.; g, Hyd. Lab.

	Name and Location	No. Engr.	No. Cur.	Sems. or Q.	Courses Taught in					Equiv. of Sem. Hr. Req'd						
					Mech.	M.E.	C.E.	Engr'g	Other	a	b	c	d	e	f	g
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
114	Toledo U., Toledo, Ohio	293	4	S		g	f		abcd	3	3	4	---	—	3	1
115	Tufts Coll., Medford, Mass.	370	4	S			cdf*g*		ab	7[3]	---	6	1	—	3	—[3]
116	Tulane, New Orleans, La.	297	4	S		df*g*		abc	e	3	---	6	1	3	3	—[3]
117	Union Coll., Schenectady	—	2	S				abcdfg		6	---	4½	---	—	3½	---
118	Utah U., Salt Lake City	428	8	Q		abcde	fg			8	---	---	2½[2]	2	2	1½
119	Valparaiso, Val., Ind.	55	4	S			abcdfge			5	---	5	4	---	3	---
120	Vanderbilt, Nash.	—	3	Q			abcf			2	4	4	—	—	2	—
121	Vermont U., Burlington	106	3	S			defg	abc		3	3	3	1	1	3	1
122	Villanova C., Villanova, Pa.	174	4	S			abcdef			2	3	3	—[3]	2[2]	3	—
123	Va. Mil. Inst., Lexington	—	2	S				abcd*efg*		6	---	3	—[3]	—[3]	3	---
124	Va. Poly., Blacksburg	1145	11	Q	abcdef	*g*				2	2	2[2]	2	---	2	—[3]
125	Va. U., Charlottesville	183	4	Q				abcdefg		4	---	2	1½	2	2	1½
126	Washington U., St. Louis.	366	6	S			d*e*		abcf	4	---	6[2]	1[2]	—[3]	with c	—
127	Wash. U., Seattle	1370	6	Q		de	abcd*efg*			2[2]	---	2[2]	2[2]	---	3½	---
128	Wash. St. C., Pullman	584	11	S		de	abcf*g*			5[2]	---	4	1½	2	3	—[3]
129	W. Va. U., Morgantown	400	5	S	abcd		*ef*			3	3	4	1	—[3]	3	—
130	Wisconsin U., Madison.	—	6	S	abcde		f[5]g[5]			5	---	5	2[2]	---	3[2]	---
131	Wyoming U., Laramie	309	4	Q			abcdef			2½	3½	3½	1½	2	3½	—
132	Worcester, Worcester, Mass.	533	5	S		abcd*efg*				3	3[2]	4[2]	5[2, 11]	—[3]	2½	with d
133	Yale, New Haven, Conn.	423	5	S	abcd*fg*					8[2, 3]	---	5[2]	---	—	—[3]	—[3]

TEACHING OF MECHANICAL ENGINEERING SUBJECTS TO ELECTRICAL ENGINEERING STUDENTS*

AN INFORMAL DISCUSSION BY ROBERT L. SPENCER

Dean of Engineering, University of Delaware

In considering what to say concerning this subject I thought of a number of questions which might well be considered in our discussion. I should like to discuss them with you quite informally. Furthermore, I should like to limit our discussion to the undergraduate program.

I. *What is the purpose of the training in electrical engineering given in our undergraduate schools?*

In considering this subject the first question which arose in my mind was the purpose for which we are training our electrical engineering graduates. I wanted to know how many of them become successful electrical engineers. A young man who graduates from college at the average age of 22 has, according to the actuarial tables, a life of 40 years and 9 months ahead of him. I went then to the reports of the United States Office of Education and totaled up, so far as I was able, the number of graduates in electrical engineering for the last 41 years. This was supplemented by the reports of attendance in our own JOURNAL. Both reports are only partially complete, but it would appear that at least 54,000 students have been graduated in electrical engineering during the past 41 years. On February 1, 1937, there were 15,352 members of the American Institute of Electrical Engineers. If we may say, then, that every electrical engineer who is successful will become a member of the Institute and say further that every member of the Institute may be considered a successful electrical engineer, then of the graduates in electrical engineering for the past 41 years, only 28 per cent remain in electrical engineering and become successful enough in it to join the Institute. It would appear then that at least 75 per cent of the men we are now graduating in electrical engineering will not remain in their own specialized field but will branch out into other fields of engineering or get away from the profession entirely. We have our rapidly growing graduate schools

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to provide specialized training for the electrical engineer who is going ahead in his profession. In our undergraduate curriculum, I think we should give very serious consideration to the seventy-five or higher percentage who are going to use the course as training for a successful life in one of the many other related fields provided by our modern world of applied scienee.

II. *What is the relation of mechanical engineering to electrical engineering?*

Our modern civilization is the result of rapid adaptation of electricity and the principles of the machine to the use of mankind. The work of the electrical engineer and that of the mechanical engineer are closely related, interdependent and inseparable. In the field of electric power the electrical enginer looks to th prime mover of the mechanical engineer to drive the generator; to the principles of machine design for the design of a large part of the generator; to the methods and machines of the mechanical engineer to manufacture the generator; and to the machines of the mechanical engineer to use a large part of the generator's output. In the field of electrical communication the electrical engineer again looks to the mechanical engineer for energy and for at least a large part of the design and manufacture of the apparatus used. Likewise the mechanical engineer is dependent on the electrical engineer for energy to drive his machines and for the distribution of this energy to the place where it is convenient for use. The electrical engineer and the mechanical engineer must work hand in hand. The curricula used in training these two branches of the profession should reflect their interpendence and close relationship.

III. *Which are mechanical engineering subjects?*

The question might arise as to whether such subjects as drawing, mechanics, hydraulics, industrial management, etc. are mechanical engineering subjects, whether they belong in some other degree-granting department, or whether they belong in a department by themselves. The problem is an administrative one depending on the size of the institution and local conditions. I have included in our discussion all subjects which are at all frequently taught in the mechanical engineering division in any of our schools —this without meaning to imply that the teaching of all of these subjects should be administered under the division of mechanical engineering. The subjects to be considered fall into the following groups:

1. Drawing (including also descriptive geometry and elementary machine design).

2. Shops (including also classroom courses in shop processes and methods).
3. Heat Power (including also thermodynamics and mechanical laboratory courses).
4. Mechanics (including also strength of materials, materials of construction and materials testing laboratory).
5. Hydraulics (including laboratory).
6. Industrial Management.

IV. *What are most institutions doing?*

To attempt to make any sort of tabulation and digest of the work being done in all the engineering colleges in the country would involve a tremendous amount of labor—perhaps not worth while. Some typical group of creditable colleges must be selected. I took the thirty-one colleges on the first published list of institutions accredited by the Engineers' Council for Professional Development in electrical engineering. This list is a typical cross section of American engineering education. It includes large colleges and small—city colleges and country colleges—coöperative colleges and full time colleges—land grant colleges and those supported by the state, the city and by private endowment—old colleges and young ones—schools which are one division of a university thoroughly imbued with the liberal arts tradition and colleges which are exclusively schools of technology—institutions with well organized graduate division and institutions offering undergraduate work alone.

In evaluating the work for each subject I have allowed one credit for three hours per week of work in classroom, laboratory and/or preparation for a semester term of sixteen weeks. In general, one credit is allowed for each hour per week of class work on the assumption that two hours of preparation are required for each hour of class recitation. In shops and drafting room courses where no outside preparation is required one credit is allowed for each three hours per week of attendance. In courses requiring outside work in the form of reports, etc., one credit is allowed for each two hours of attendance. Credits listed in the catalogs of some institutions are changed in Table I to suit this basis.

V. *What is being done at the University of Delaware?*

The first two years of the curricula in electrical engineering and mechanical engineering at Delaware are identical. We teach both divisions the same English, the same mathematics, the same fundamental science, the same drawing room courses, and the same shop courses.

TABLE I

MECHANICAL ENGINEERING SUBJECTS TAUGHT TO ELECTRICAL ENGINEERING STUDENTS AT 31 INSTITUTIONS ON THE FIRST LIST OF INSTITUTIONS ACCREDITED BY E.C.P.D. IN ELECTRICAL ENGINEERING

	Drawing and Machine Design				Shops							Heat Power					Mechanics, Str. of Materials and Matls. of Construction					Hydraulics			Industrial Management			Total
																	Mechanics											
	Drawing	Desc. Geom.	Kin. and Mach. Design	Total	Wood	Pattern	Foundry	Welding	Forge	Machine	Total	Thermo. and Heat Power	Mech. Lab.	Stm. Eng.	Stm. Turb.	Total	Statics	Kinetics	Str. of Matls. or Matls. of Const.	Matls. Lab.	Total	Hydraulics Recitation	Hydraulics Laboratory	Total	Industrial Management	Industrial Psychology	Total	
1. Brown	3	3	0	6	0	0	0	0	0	0	(3)	6	0	0	0	6	3	3	5	1	12	2	1	3	0	0	0	30
2. Carnegie	3	3	3	9	0	0	1	1	1	1	4	4	2	0	0	6	3	3	5	1	12	2	1	3	0	0	0	34
3. Clarkson	4	2	0	6	0	0	0	0	0	1	1	6	2	0	0	8	3	3	6	0	12	3	0	3	0	0	0	30
4. C.C.N.Y.	2	4	5	11	—	—	—	—	—	—	4	7	1	0	0	8	—	4	2	1	7	3	0	3	0	0	0	33
5. Columbia (5 yr.)	3	3	2.5	8.5	0	0	0	0	0	0	(3)	5.5	2	0	0	7.5	3	3	4	0	10	2	0	2	0	0	0	31
6. Cooper Union	1	4	12	17	0	0	0	0	0	0	0	6	2	0	0	8	—	10	—	4	(1)	15	2	(1)	3	0	0	0	43
7. Cornell (reg. 4 yr.)	3	3	7	13	1	0	0	0	0	2	(1)4	6	8	0	0	14	—	5	—	7		12	2	0	2	2	0	2	47
8. Delaware	3	3	4	10	0	1	0	1	0	2	4	4	10	0	0	14	4	8	4	6	1.5	15.5	3	1.5	4.5	3	0	3	51
9. Drexel (3 quart.)	2.7	2.7	5.7	11	0	0	0	1	0	2	3	5.3	3	0	2	10.3	2.7	4.7	2	2.7	3	10.3	2	1	3	0	0	0	37.6
10. Hopkins	3	3	3	9	0	0	0	0	0	0	0	9	6	0	0	15	—	4	—	7	0	11	3	0	3	3	0	3	41
11. Lafayette (tech.)	4	2	5	11	0	1	1	0	0	2	4	4	2	0	0	6	—	5	—	4	2	11	3	0	3	3	0	3	38
12. Maine	4	2	3	9	0	0	0	0	0	3	3	6	0	0	0	6	—	6	—	0	0	6	0	0	0	0	0	0	24
13. M.I.T. (VI)	3	3	0	6	0	0	0	0	0	2	2	8	1.5	0	0	9.5	3	6	3	6	0	12	3	0	3	0	0	0	32.5
14. New Hampshire	6	3	0	9	1	0	1	0	0	3	5	7	2	0	0	9	—	6	—	0	1	7	2	0	2	5	0	5	37
15. New York U.	2	3	3	8	0	0	0	0	0	0	(3)	9	2	0	0	11	3	6	3	5	2	13	2	1	3	(3)	(2)	(5)	43

TABLE I—*Continued*

	Drawing and Machine Design				Shops							Heat Power					Mechanics, Str. of Materials and Matls. of Construction					Hydraulics			Industrial Management			Total
	Drawing	Desc. Geom.	Kin. and Mach. Design	Total	Wood	Pattern	Foundry	Welding	Forge	Machine	Total	Thermo. and Heat Power	Mech. Lab.	Stm. Eng.	Stm. Turb.	Total	Mechanics: Statics	Mechanics: Kinetics	Str. of Matls. or Matls. of Const.	Matls. Lab.	Total	Hydraulics Recitation	Hydraulics Laboratory	Total	Industrial Management	Industrial Psychology	Total	
16. Newark	8		3	11	0	0	0	0	0	0	0	9	2	0	0	11	4	8	4	6	1.5	15.5	3	0	3	6	0	6	46.5
17. Norwich	4	3	0	7	0	0	0	0	0	0	0	9	2	0	0	11	3	6	3	3	0	9	3	0	3	0	0	0	30
18. Penn State	2	2	2	6	0	0	1	0	1	1	3	3	3	4	0	10	4	8	4	1	1	10	2	2	2	3	5	36	
19. Pittsburgh	4		5	9	0	0	0	0	0	1	1	4	1	0	0	5	4	6	2	3	0	9	2	2	4	0	0	0	28
20. Poly. of Brooklyn	3		4	7	0	1	1	0	0	2	4	7	2	0	0	9	—	5	—	3	1	9	2	0	2	2	0	2	33
21. Princeton	5.5	4	5.5	15	0	0	0	0	0	0	0	5	3	3	0	11	3	6	3	3	2.5	11.5	2	1.5	3.5	2	0	2	43
22. Rensselaer	3.5	3	3	9.5	—	—	—	—	—	—	3	3	2	2.5	0	7.5	—	4	—	5	1	10	3	0.5	3.5	0	0	0	33.5
23. Rhode Island	7	3	3	13	0	2	1	0	1	0	4	9	0	0	0	9	—	5	—	2	3	10	3	0	3	0	0	0	39
24. Rutgers	3	3	3	9	0	0	0	0	0	0	0	6	2	0	0	8	3	6	3	6	2	14	3	1	4	0	0	0	35
25. Swarthmore	3	3	3	9	—	—	—	—	—	—	3	6	2	0	0	8	4	4	0	4	2	10	4	0	4	4	0	4	38
26. Syracuse	4	2	7	13	1	0	1	0	1	1	(1)5	6	1	3	0	10	—	6	—	0	1	7	3	0	3	2	0	2	40
27. Tufts	8		4	12	0	0	1	0	0	1	2	7	3	0	0	10	—	3	—	3	1	7	3	0	3	0	0	0	34
28. Union	4	3	0	7	0	0	0	0	0	0	0	6	0	0	0	6	—	6	—	8	1	15	3	0.5	3.5	0	0	0	31.5
29. Vermont	10	3	0	13	0	0	0	0	1	1	2	6	3 or 0	0	0	6 or 9	6	9	3	1	1	11	3	1	4	0	0	0	36 or 39
30. Worcester	5	3	2	10	0	1	0	0	0	1	2	2	2	2	0	6	3	6	3	4	0	10	2.5	1	3.5	0	0	0	31.5
31. Yale	3	3	0	6	0	0	0	0	0	0	0	5	1	0	0	6	4	8	4	4	2	14	0	0	0	0	0	0	26
Minimum	1	2	0	6	0	0	0	0	0	0	0	2	0	0	0	5	2.7	3	2	0	0	6	0	0	0	0	0	0	24
Maximum	10	4	12	17	1	2	1	3	1	3	7	9	10	4	2	15	6	10	4	8	3	15.5	4	2	4.5	6	3	6	51
Average	3.7	2.9	3.2	9.7	0.1	0.2	0.3	0.1	0.2	0.9	2.3	6.0	2.3	0.5	0.1	8.9	3.5	6.0	2.9	3.9	1.1	10.9	2.4	0.5	2.9	1.2	0.2	1.4	35.6
Most common	3	3	3	9	0	0	0	0	0	0	4	6	2	0	0	9	3	6	3	6	1	12	3	0	3	0	0	0	

A credit is allowed for three hours per week of work (recitation, laboratory and/or preparation) for a semester term of 16 weeks.

The third, or junior year, at Delaware is identical in the two curricula except for one small branch. The electrical engineers take Electrical Design and Differential Equations, while the mechanical engineers are taking Machine Design. Both groups take the same work in the subjects of Hydraulics, Hydraulics Laboratory, Elementary Electricity Theory, Electrical Laboratory, Thermodynamics of Vapors and Gases, Mechanical Laboratory, Mechanics, Strength of Materials, Materials Laboratory, and Government.

In the senior year at Delaware the two courses are quite similar. Both electrical and mechanical engineers take the same course in Economics and in English throughout the year, the same course in Alternating Current Machinery and Electrical Laboratory, and in Industrial Management. The electrical engineers have a classroom course in Electrical Power Plant Machinery and High Frequency Alternating Currents, while the mechanical engineers are studying a course in Advanced Heat Power. The courses in Mechanical Laboratory are very similar. Both electrical and mechanical engineers take one hour of recitation work, then the mechanical engineers take two afternoons of laboratory work while the electrical engineers take only one. The electrical engineers write undergraduate theses, which the mechanical engineers do not. This undergraduate thesis is really an additional afternoon of Electrical Laboratory where the work is done in some particular field of investigation and then written up in the form of a report more lengthy than the ordinary laboratory report.

We believe that there is such a close relationship between the work in after life done by our electrical and mechanical engineers that there should be this close relationship between the undergraduate curricula preparing them for this life work.

VI. *What about Drawing courses?*

Drawing being one of the written languages of all branches of engineering is, of course, included in the curriculum for all branches of engineering. In electrical engineering the advanced drawing will tend to be of the nature of machine design or kinematics. I find that in the 31 institutions studied, the time devoted to the drawing and machine group, including drawing, descriptive geometry, kinematics, and elementary machine design, will average 9.7 credit hours. The most common practice seems to be to allow 9 credit hours to this group, the minimum seems to be 6 credit hours, and at least one institution devotes as much as 17 credit hours to this work.

The time devoted to elementary drawing and lettering seems to average 3.7 credit hours; most commonly 3 credit hours; a mini-

mum of one credit hour; and in one case a maximum of 10 credit hours.

Descriptive geometry, or the theory of drawing, seems to be found in almost all electrical engineering curricula. An average of 2.9 credit hours is devoted to this subject. The most common practice is 3 credit hours, the minimum is 2 credit hours, and the maximum seems to be 4 credit hours.

It is a little difficult to differentiate between kinematics and elementary or empirical machine design, so I have grouped these subjects together and find that an average of 3.2 credit hours is devoted to this branch; most common practice is 3 credit hours; the minimum is no credit hours; and the maximum in one case is 12 credit hours.

At the University of Delaware we devote 3 credit hours to drawing, 3 credit hours to descriptive geometry, and 4 credit hours to kinematics and machine design, a total of 10 credit hours to the drawing and machine design group.

VII. *What about Shop courses?*

Shops in the engineering curriculum seem to be a subject of considerable discussion at the present time, and they should be under scrutiny. In the old days our college shops were manual training establishments. In an already crowded curriculum the advisability of spending the time for this manual training may well be questioned. A number of technical high schools are springing up over the country. Almost all of our first grade high schools have manual training divisions. The high school, then, is taking over this work. It is no longer necessary for the engineering college to teach shop from the manual training standpoint. A great many of our engineering colleges are considering changing the character of our shop courses and some have already taken steps in that direction. The college shop is becoming either a laboratory of industrial management or a laboratory in manufacturing processes. This looks like the right step.

In the 31 institutions studied, I find that the average time devoted to the shop group is 2.3 credit hours. The most common practice is 4 credit hours. Some institutions devote no time to this work, and the maximum is 7 credit hours. The favored shop is the Machine Shop, and the average is 0.9 credit hour in the 31 institutions. The most common practice is to devote no time to this shop; the minimum is none; and the maximum is 3 credit hours. Other shops which I found in the curricula of the various institutions are Wood Shop, Pattern Shop, Foundry, and Forge Shop.

At the University of Delaware we are taking decided steps to change our shops from manual training establishments into lab-

oratories of industrial management. Under this new method of attack we are devoting 4 credit hours to shop work in both the electrical and mechanical engineering curricula. This is divided up into 1 credit hour of Pattern Shop, or one afternoon per week for one semester, in which we study the foundry from textbooks and visits to industrial plants; 1 credit hour (1 afternoon per week) of Welding, including both gas welding and electric welding; and 1 afternoon per week for two semesters of Machine Shop.

VIII. *How much time for Heat Power courses?*

The heat power group of subjects, including thermodynamics, heat power, mechanical laboratory, steam engines and turbines, is an important group for the electrical engineer. We find considerable time devoted to this group in almost all of the electrical engineering curricula. It is a little hard to tell from the catalog descriptions whether the classroom subjects are thermodynamics or heat power, so that I have grouped these two under one heading and find that the average in the 31 institutions is 6 credit hours devoted to this subject; most commonly 6 credit hours; in one institution 2 credit hours; and a maximum of 9 credit hours. Mechanical laboratory is found in the electrical engineering curricula almost without exception. The average time devoted to this subject is 2.3 credit hours; most commonly 2 credit hours; one institution devotes no time to this subject; and one institution devotes 10 credit hours. I find five institutions offering a course in steam engines and one a course in steam turbines. I hope that the course covers operation or thermodynamics rather than valve gears or design. The total for the heat power group seems to average 8.9 credit hours; most commonly 9 credit hours; a minimum of 5 credit hours; and a maximum of 15 credit hours.

At the University of Delaware the electrical engineers take a 4 credit hour classroom course in thermodynamics and heat power. In addition they take one class hour and three laboratory hours, with reports to be prepared outside, of mechanical laboratory for two years and credited at 10 credit hours. In all, the electrical engineer takes 14 credit hours of work in the heat power group.

IX. *How much for Mechanics?*

The group, including theoretical and applied mechanics, strength of materials, and materials of construction, is the basis of all engineering, and as to be expected, we find these subjects in all electrical engineering curricula. In the 31 institutions studied the average time devoted to these subjects is 10.9 credit hours; the most common practice is 12 credit hours; the minimum is 6 credit hours; and the maximum is 15.5 credit hours. The group may be divided

up into statics, which average 3.5 credit hours, most commonly 3 credit hours, minimum 2.7 credit hours, and a maximum of 6 credit hours; kinetics, which average 2.9 credit hours, most commonly 3 credit hours, minimum 2 credit hours, and maximum 4 credit hours; materials testing laboratory, which averages 1.1 credit hours, most commonly 1 credit hour, in some institutions no credit hours, and in some a maximum of 3 credit hours; strength of materials and materials of construction, averaging 3.9 credit hours, most commonly 6 credit hours, in some institutions no credit hours, and in some institutions as much as 8 credit hours.

At the University of Delaware we devote 4 credit hours to statics, 4 credit hours to kinetics, 1.5 credit hours to materials testing laboratory, and 6 credit hours to strength of materials in the electrical engineering curriculum. Our total is 15.5 credit hours for the mechanics group.

X. *How about Hydraulics?*

Hydraulics is another field closely connected with electrical engineering. I find that the average practice in the 31 institutions studied is 2.9 credit hours for this subject The most common practice is 3 credit hours, the minimum is 0, and the maximum is 4.5 credit hours. In many places this work is divided up into the classroom work and laboratory, scheduled as separate subjects. Classroom work averages 2.4 credit hours, the most common practice is 3 credit hours, the minimum is 0, and the maximum is 4 credit hours. The laboratory work averages 0.5 credit hour, most commonly 0, minimum 0, and maximum 2 credit hours.

At the University of Delaware we require of electrical engineering students a 3 credit hour classroom course in hydraulics for one term. This is accompanied by one afternoon per week of laboratory work with the reports to be prepared outside, carrying a credit of 1.5. This gives us a total of 4.5 credit hours devoted to hydraulics and hydraulics laboratory.

XI. *Should Industrial Management be included?*

Courses in the industrial management group are, I feel, important to any engineer and are too often not included in the electrical engineering curriculum. In introducing this subject to our students I like to point out the thought that the United States is the foremost industrial nation of the world. Our country is commonly conceded by other nations to hold this enviable position. I also point out that it is debatable whether our scientists, our engineers, or our financiers are any more clever than those of the other nations of the world. The position of our country in industry must be due to the American system of industrial management. Other nations,

realizing this, are attempting to adopt our methods of mass production and scientific management, so far with only partial success. If our country is to maintain her position as the leader in industry, then all of our young engineers must be given training in the American system of industrial management.

The average time devoted to the subject of industrial management in the 31 institutions studied seems to be 1.2 credit hours. Most commonly the subject is not taught at all, and the maximum time devoted to this subject is 6 credit hours.

At the University of Delaware we require one survey course in industrial management of 3 credit hours of all electrical engineers. I wish we had time and facilities to expand this group to include time and motion study, plant location and layout, and industrial psychology. We are changing our courses in shop practice so that in the not very distant future they will become truly a division of industrial management.

XII. *How keep the electrical engineer interested in mechanical engineering subjects?*

The question may arise as to the device we use to rouse the interest of the electrical engineering student in mechanical engineering subjects. We do not use any special device. We find that it is not necessary. The electrical engineering student is fully as interested in mechanical engineering subjects, so far as they go, as are our mechanical engineering students. This, we find, applies to drawing and machine design, mechanical laboratory, our shops, our courses in hydraulics, and our courses in mechanics and strength of materials.

XIII. *How conduct the laboratory and classroom exercises?*

In classroom exercises we use the question and answer method almost exclusively. Our classes are small and informal. The student spends most of his time at the blackboard. We seldom use the formal classroom lecture. In what little talking we do before the class we very briefly point out the place of the day's textbook assignment in the general plan of what has been covered and what is to come in the course. Or we present from our own experience or from literature which the student is not expected to have read, examples or applications of the day's work in industry. We never repeat in lecture form the information given in the day's textbook assignment. Our classroom talks are very brief and very informal. The formal classroom lecture may tickle the conceit of the instructor by thus demonstrating to a group of young students the instructor's profound knowledge of subjects which, while appearing new and wonderful to the students, may to the initiated be quite

elementary. We try to inspire in our students self confidence in their own ability to get engineering principles directly from published textbooks and literature, to demonstrate these principles and to apply these principles in the solution of engineering problems. We feel that the duty of the undergraduate engineering school teacher is (1) to select or prepare in writing proper material, (2) to assign this material to the student in reasonable and adequate amounts, (3) to see that the student accomplishes a regular and sufficient amount of work, (4) to see that the student draws correct conclusions from his work, (5) to offer kindly and constructive criticism when the student makes mistakes, and (6) to inspire the student to carry his work on to the full limit of his physical and mental capacity.

In our shops and laboratories the students do all the work done during the class hour. They put on overalls and get their hands dirty. If it is a turbine test we are running for the day, the students themselves operate the machine, take care of the lubrication, warm up the line, bring the turbine up to speed, put on the load, make the necessary adjustments, install and read the test instruments, take off the load, stop the machine, bleed the lines, and clean up. The instructor and laboratory mechanic stand by to instruct and offer advice to protect the students and the equipment, but in no case do they do the work for the students. The young men get from the instrument room all the necessary testing instruments and apparatus, set it up, adjust it, use it, take it down, clean it and put it away. We don't believe in picking up after our students. They are trained to clean up after themselves. By this method of approach every student learns how to operate, adjust, care for and sometimes to repair every machine, instrument and piece of equipment in the laboratory.

XIV. *What total time in the electrical engineering curriculum should be devoted to mechanical engineering subjects?*

To summarize, in general the credit hours of the electrical engineering curriculum devoted to a total of those subjects listed in Table I as mechanical engineering, vary from 24 to 51 credit hours and average 35.6 credit hours in the 31 institutions studied. Of a 144 credit hour curriculum this will average 24.7 per cent.

At Delaware we devote 51 credit hours of a 157.5 credit hour curriculum to those subjects listed in Table I. This is 32.4 per cent.

A FUNDAMENTAL COURSE IN MECHANICAL ENGINEERING *

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In attempting to define a fundamental course in Mechanical Engineering, the writer fully realizes the controversial nature of the problem. One has only to discuss the problem informally with teachers, professional engineers and business men to realize the many viewpoints that exist. Dr. Butler, of Columbia, recently stated that for the next 100 years, world affairs will be in the hands of engineers and pleaded for more attention to public affairs in our curriculum. One wonders whether a course in Scavengering Engineering would be appropriate. Dr. Hutchins, of Chicago, sees the American universities falling over themselves to be of service to the public by establishing vocational courses of all kinds. He strongly protests that this is not their function. Dr. Hotchkiss, of Rensselaer, reminds us that our function is to develop good engineers as well as good citizens and suggests that a sound engineering training can be had only in engineering colleges while other means are available for the development of social, political and moral standards. A speaker at the December meeting of the A.S.M.E. called for a course in medicine to be included in all engineering studies to prepare the student to deal safely with toxic gases in industry. Industrial leaders usually see the problem from the viewpoint of their industry and demand more specific training to meet their needs.

The various conflicting views that seem to exist on the subject of a M.E. curriculum lend courage to the writer to attempt to set down his views. No attempt is to be made to establish a standard course; the writer realizes that the course must be flexible enough to meet the needs of local conditions. However, he is reminded of a statement by Mr. Funk, of the Philadelphia Electric Company, that the main criticism of our work seems to be that "the curriculum resembles a wall made by throwing stones together instead of placing the stones in a definite pre-arranged pattern." It is to try to develop that pattern that this paper is presented.

* Presented at Summer Conference on Mechanical Engineering, S. P. E. E., June 28–29, 1937.

A study of the excellent S. P. E. E. Report of 1928–29 gives one a good picture of the development of our work up to that time. Professor Magruder, of Ohio State, in his S. P. E. E. paper of October 1933 brings the picture up to that time. A study of recent catalogues then brings the material up to date. One observes a cyclic change in the general pattern of our curriculum. In the early days, the course was 69 per cent general academic; in 1923 it was 42 per cent general, while at present it seems to be about 44 per cent general academic and 56 per cent Engineering. The schedule to be proposed by the writer makes the pattern 48 per cent general and 52 per cent Engineering.

In an attempt to get a picture of the M.E. course as now given, a study was made of a number of catalogues from colleges spread over the country and representing a variety of ideas. The study was limited to the four year schedule. The various subjects offered was listed by years (Freshman, etc.) and from this list, a composite M.E. course was developed which included those subjects occurring with the greatest frequency. In studying the list of courses, one observes the following variety of offerings:

Year	Number of Courses Listed
Freshman	13
Sophomore	22
Junior	23
Senior	23

This would indicate that the Freshman year has become more or less standardized while considerable difference of opinion exists as to the content of the remaining three years. Based on this survey, the following four year schedule is presented as representing a composite course in Mechanical Engineering as it is now given.

The general topic of this Convention is to examine our work in the light of changing times. This is a difficult task because one can seldom gain a perspective view of a period while living in that period. However, there is little doubt but that our work is becoming more and more professional. To be sure, we are quite concerned with the definite mechanical engineering problem of power generation, industrial production and routine design. In the past, our graduates dealt mainly with other engineers and plant management. To-day, they are meeting the public at large in increasing numbers, in quite the same manner that the doctor and lawyer meets the public. The designer to-day must develop a mechanism that not only satisfies the producer, but also a more critical consumer. He must ever keep in mind the psychology of the consumer. As an example, my wife refuses to buy milk in the new cardboard containers recently developed. She claims she can-

COMPOSITE M.E. COURSE AS NOW GIVEN. BASED ON A 15 WEEK SEMESTER WITH 50 MINUTE PERIODS

	Clock Hours	Periods	
		1st Sem.	2nd Sem.
Freshman Year			
Mathematics (Alg., Trig., Anal. Geometry)	100	4	4
Physics	100	4	4
General Chemistry	150	6	6
Drawing	75	3	3
English	75	3	3
History	25	1	1
Shop Work	75	3	3
Physical Training	50	2	2
	650	26	26
Sophomore Year			
Calculus	100	4	4
Analytical Mechanics	75	3	3
Chemistry (Qual. Anal.)	75	3	3
Drawing and Desc. Geometry	100	4	4
Mechanism	50	2	2
English	75	3	3
Physics	100	4	4
Shop Work	75	3	3
Physical Training	50	2	2
	700	28	28
Junior Year			
Thermodynamics	50	4	0
Applied Thermodynamics	37	0	3
Heat Laboratory	37	0	3
Strength Materials and Lab.	75	3	3
Electricity and Lab.	150	6	6
Machine Design	150	6	6
Hydraulics	37	3	0
Shop Work	75	3	3
Economics	50	2	2
	660	27	26
Senior Year			
Mech. Eng. Lab.	100	4	4
Power Plants	75	3	3
Turbines	25	2	0
Internal Combustion Engines	25	0	2
Structures (Graphics)	37	0	3
Hydraulic Lab.	37	3	0
Thesis	100	4	4
Management	75	3	3
Metallurgy	50	2	2
Engineering Option	75	3	3
Non-Engineering Option	75	3	3
	674	27	27

SUMMARY OF COMPOSITE COURSE

	Clock Hours		Per cent
General Academic			
Mathematics	200		7.5
English	150		5.6
History	25		0.9
Economics	50		1.8
Management	75		2.8
Senior Option	75		2.8
Chemistry	225		8.4
Physics	200		7.5
Anal. Mechanics	75		2.8
Physical Education	100		3.7
Total	1175		43.8
Engineering			
Electricity	150		5.5
Shop Work	225		8.4
Thesis	100		3.7
Engineering Option	75		2.8
Hydraulics	75		2.8
Heat Power Group			
Thermo. and App. Thermo.	87		
Heat Laboratory	137		
Power Plants	75		
Turbines and Int. Comb. Eng.	50	(349)	13.0
Machine Design Group			
Drawing and Des. Geom.	175		
Strength of Materials	75		
Machine Design and Mechanisms	200		
Metallurgy	50		
Structures	37	(537)	20.0
Total	1511		56.2
Grand Total	2686		100.0

not tell how much milk is left in the bottle and has a feeling that the container will collapse in her hand. The economic idea of the cardboard container is sound. The engineering salesman of to-day does not only contact a purchasing agent; he must first determine the needs of his client for the article; fit the article to the needs of his client; instruct the client in the use of the article and in many cases educate the public to consume his client's product. This calls for a sound basic training in general science; the application of general science to basic engineering problems, and an increasing interest in social and political psychology.

It is the writer's belief that engineering colleges must first take care of the technical problem and treat as a secondary matter the social and political problem in the limited four year period at our disposal. He believes in the encouragement of Junior Colleges and vocational schools to care for the engineering mechanic, draughts-

man and detail designer. The first two years of our course should be definitely treated as a Junior College and only those well qualified students encouraged to continue for the engineering degree. He believes in a limited introduction of social and political problems in the undergraduate course by means of lectures and discussions at various intervals in the four year period.

In examining the composite curriculum presented above, one is inclined to feel that it meets our needs. It has been developed over a period of years and has been modified from time to time to meet changing conditions. However, these modifications are like one's visit to the dentist. A tooth is filled to cause the least discomfort to the patient even though in the grinding, considerable decay is left behind to cause future trouble. A tooth is pulled only after considerable prayer. Such is the case with Shop Work. Some 225 hours or 8.4 per cent of our time is devoted to this course and in a large number of cases the course is essentially Manual Training. The writer proposes to decrease this time to 100 hours of lectures, visits, and laboratory work on shop methods and machine tool practice. If we feel the need for additional training, it should be had by required summer work in industry.

In Chemistry, some 225 hours are spent on General Chemistry and Qualitative Analysis. The proposed schedule will limit this course to 150 hours, this time being devoted more to a study of Physical Chemistry than the present general course.

In Drawing and Descriptive Geometry, it is proposed to reduce the time from 175 hours to 150 hours. It is felt that the student gains practice in drawing in such courses as mechanism drawing and machine design. The writer proposes to discard the present course in Hydraulics in favor of a more general course in Fluid Mechanics.

The problem of Mathematics has always been a troublesome one in the engineering curriculum. If it were possible to rely on the high school courses in algebra, trigonometry and analytic geometry, more time would be available in college for calculus and its applications. The writer does not feel that this is the case and recommends the continuation of freshman mathematics followed by calculus in the second year. He further proposes to increase the time allotted to Calculus so as to include the elements of differential equations. It is further proposed to increase the scope of Analytical Mechanics to cover two years work, the sophomore and junior years. In the junior year advanced problems in Mechanics should be considered such as dynamic balancing, critical speeds, free and forced vibration, advanced light and sound problems, etc. This year would have the advantage of such tools as calculus and differential equations.

In view of the above factors and after a careful consideration of the problem in general, the writer proposes the following curriculum as a guide to a fundamental course in Mechanical Engineering.

It is beyond the scope of this paper to discuss the content of the various subjects included in this curriculum. However, a few words as to the general pattern is necessary. The writer has listed by name the various subjects he feels should be included in a fundamental Mechanical Engineering Course. In addition, three subjects have been listed, totaling 250 hours or 9.2 per cent of the time, that might be used as various departments see fit. These subjects are Engineering Option, Non-Engineering Option and Thesis.

The subjects listed in the Freshman and Sophomore years form a fairly complete pre-engineering course. The writer feels that after this period, a more carefully selected group should be encouraged to complete the four year schedule. Those who do not fully meet all requirements should be encouraged to end their formal schooling here. The training these men have received should fit them for many non-professional jobs in industry.

The writer has attempted to make the various sub-divisions of Mechanical Engineering as continuous as possible over the four year period. As an example, in Machine Design, subjects directly related will be found in each of the four years. The same is true of Heat Power if one considers the content of the courses in Physics and Physical Chemistry. Work in Management and related subjects can be introduced in the first two years through selected reading in the English course.

In conclusion, the writer would like to refer again to Mr. Funk's comparison of our work to a wall built by throwing stones together. There is considerable truth in this statement. Take, for instance, those subjects directly given within the department. Let us consider first those subjects directly related to Machine Design. One would list the following: Drawing, Descriptive Geometry, Analytic Mechanics, Mechanisms, Engineering Materials, Strength of Materials, Metallurgy, Graphics and Machine Design. Possibly shop work might be included. In a large number of colleges, each of these subjects may be under the direction of as many individuals, and may be given in three or four different departments. What chance do we have of making a definite consecutive program of these courses under such diversified responsibility. The writer would suggest that the Professor of Machine Design, or a similar faculty member, be given direct charge of this group of courses and be responsible for their continuity.

The same condition exists in Heat Power. In many cases, classroom and Laboratory are distinct and quite separate. In

PROPOSED COURSE IN MECHANICAL ENGINEERING. BASED ON A 15 WEEK SEMESTER AND 50 MINUTE PERIODS

	Clock Hours	Periods	
		1st Sem.	2nd Sem.
Freshman Year			
Mathematics (Alg., Trig., Anal. Geometry)	100	4	4
Physics	125	5	5
Physical Chemistry	150	6	6
Drawing and Desc. Geom.	150	6	6
English	75	3	3
History	50	2	2
Physical Education	50	2	2
	700	28	28
Sophomore Year			
Calculus and Diff. Equations	150	6	6
Analytic Mechanics	75	3	3
Mechanism (Mach. Des.)	75	3	3
Physics	125	5	5
Shop Practice	100	4	4
English	75	3	3
Engineering Materials	50	2	2
Physical Education	50	2	2
	700	28	28
Junior Year			
Analytical Mechanics	75	3	3
Heat Engineering Theory	88	4	3
Heat Laboratory	37	0	3
Strength of Materials and Lab.	75	3	3
Electricity and Lab.	150	6	6
Fluid Mechanics	125	5	5
Metallurgy and Lab.	75	3	3
Economics	50	2	2
	675	26	28
Senior Year			
Machine Design	150	6	6
Graphics and Structures	50	2	2
Engineering Lab.	100	4	4
Power Plants	50	2	2
Management	100	4	4
Engineering Option (Heat. and Vent.) (Int. Comb. Eng.) (Turbines)	75	3	3
Non-Engineering Option	75	3	3
Thesis	100	4	4
	700	28	28
Total	2775		

SUMMARY OF PROPOSED COURSE

	Change	Clock Hours	Per Cent
General Academic			
Mathematics	+50	250	9.0
English	0	150	5.3
History	+25	50	1.8
Economics	0	50	1.8
Management	+25	100	3.6
Senior Option	0	75	2.8
Chemistry	−75	150	5.3
Physics	+50	250	9.0
Analytic Mechanics	+75	150	5.3
Physical Education	0	100	3.6
Total	+150	1325	47.5
Engineering Course			
Electricity	0	150	5.3
Shop Work	−125	100	3.6
Thesis	0	100	3.6
Engineering Option	0	75	2.8
Fluid Mechanics (Hydraulics)	+ 50	125	4.6
Heat Power Group	− 75		
Thermo. and Applied Thermo.		87	
Heat Laboratory		138	
Power Plants		50	9.8
Machine Design Group	+ 88		
Drawing and Desc. Geom.		150	
Strength of Materials		75	
Metallurgy		75	
Engineering Materials		50	
Structures		50	
Mechanisms		75	
Machine Design		150	22.8
Engineering Total	− 62	1450	52.5
Grand Total	+ 88	2775	100.0

many cases, they work at cross purposes. In some cases, I am sorry to say, one group belittles the work of the other. Why not have one management here, with interchanging of instructors between class and laboratory to better weld these groups together.

The Department Head is charged with the coördination of the entire program. However, in many cases, he has little or no control of the courses offered Mechanical Engineering students by other departments. Department Heads should concern themselves more with this problem. The writer feels that if this problem is diplomatically attacked, it will result in better instruction being given to students when they take courses outside of the department. After considerable study, the writer is of the opinion that our problem is not so much one of curriculum content as it is of curriculum management and coördination.

COMMENTS FROM INDUSTRY REGARDING PRESENT-DAY TRAINING OF MECHANICAL ENGINEERING STUDENTS *

By FRANK L. EIDMANN

Professor of Mechanical Engineering, Columbia University

In recent conferences with many executives of industrial plants in the East and the Middlewest I raised the question as to how satisfactory industry is finding our young graduates in mechanical engineering. The proportion of those who expressed dissatisfaction was so very high that I decided to investigate more extensively with the object of getting expressions from a more general cross-section of industrial firms and with the hope of determining the causes of dissatisfaction.

A questionnaire was sent to sixty firms. In the letter which accompanied the questionnaire I stated "One way of learning how satisfactory our young graduates are proving is to ask some of our friends in industry to tell us frankly as to their reaction to these young men and their training. I shall therefore greatly appreciate it if you will let me have your frank answers to the accompanying questions and I hope that you will write supplementary comment as to how, in your opinion, we teachers could do a better job in training students in mechanical engineering."

The response was very gratifying. Nearly all the firms replied and in several instances copies of the questionnaire had been sent to a number of the leading executives for comment. Practically all the replies were accompanied by lengthy letters which were in most cases signed by presidents, chairman of boards, general managers, and works managers. Great interest in the problem was expressed and the letters contained much valuable information.

Only a summary of the replies will be given in this paper. My personal comments and suggestions will be incorporated in another paper [1] to be presented some time in the future.

Question No. 1.—"In what type of work do you employ young mechanical engineering graduates? Design; research; production; sales?"

* Presented at Summer Conference on Mechanical Engineering, S. P. E. E., Cambridge, Mass., June 28–29, 1937.

[1] Editor's Note: Professor Eidmann addressed the meeting of the Middle Atlantic Section on December 11th, 1937, on "The Young Engineering Graduate in Industry."

Twenty-five per cent of the firms employ young engineering graduates in all four types of work. Most of the others employ them in only two or three of these types, and a few employ them only in design work. In the aggregate, approximately 75 per cent of the firms employ the young engineering graduates in design work, 50 per cent employ them in research and test work; 75 per cent in production; and 50 per cent in sales.

Question No. 2.—"Approximately what percentage of these men turn out to be satisfactory?"

Many of the companies find it difficult to give a definite answer to this question. Only sixty per cent venture figures. Of these 28 per cent give estimates ranging between 20 and 50 per cent of the men as proving satisfactory. The estimates of sixteen per cent range between 51 and 70 per cent. Twenty-eight per cent find between 71 and 85 per cent of the young engineers suitable. And 5 per cent find between 86 and 90 per cent of the men satisfactory. A few give estimates as low as 10 and 12 per cent as being satisfactory, while several state that "most of these young engineers prove satisfactory."

One employer comments: "About 90 per cent turn out to be reliable, hard-working employees, but not more than 25 per cent, and probably less, turn out to be top notch engineers or salesmen."

Most of the companies which report a high percentage of their young engineers as turning out satisfactorily point out that this is due to very careful selection. One such firm states that formerly only 10 per cent of the young engineers proved satisfactory, but that now the figure has been raised to 70 per cent due to careful selection.

Question No. 3.—"What in general, appears to be the trouble with those in whom you are disappointed? Personal traits, training or some other reason?"

With but few exceptions the dissatisfaction has been due to personal traits and characteristics in the young engineers. The fault most mentioned is the "Inability to get along with his associates." Other outstanding faults attributed to those falling by the wayside are: "over eagerness for advancement and unwillingness to prepare for advancement over a long enough period"; "lack of the aptitude for engineering work"; "inability to adapt themselves to the routine of operating work and at the same time avoid getting into a rut"; "lack of initiative"; "lack of self confidence."

Question No. 4.—"Do you have a training course for engineering graduates?"

Eighty per cent of the firms which replied state that they have a training course; some as long as three years, and others as short as six months. Some of the companies have well developed educa-

tional programs, while many simply have the young engineers work for a period in each important department of the plant.

Question No. 5.—"Do you prefer that your engineers have taken specialized courses or that they simply have the fundamentals in science and engineering?"

All except one employer express strong preference for the fundamentals. Several state that occasionally they select a man who has specialized in some subject of particular interest to the company.

Question No. 6.—"What weight do you give to non-engineering subjects such as English, public speaking, economics and government?"

About 15 per cent give considerable weight to English and oral expression. About the same number consider economics important. None give any weight to a study of government.

The following is typical of over 50 per cent of the replies: "In hiring young engineering graduates we have not stressed the importance of non-engineering subjects, but we feel that they are essential to the success of any graduate and that they will help materially in making progress."

Question No. 7.—"Do you prefer men who have taken a year or two of post-graduate work?

Only one employer answers "yes" to this question. Sixteen per cent prefer engineers with four-year courses except for research and highly specialized work. Twenty-one per cent state that they hire engineers who have done graduate work, as well as those from a four-year course, but that they give no preference to the men who have taken the graduate work. A few state that they much prefer men who have *not* had graduate work—in spite of the fact that the product of some of these companies is of highly technical nature. One firm states that they hire some post-graduates for highly specialized work but that they select physicists in preference for such work.

Question No. 8.—"Are you satisfied with the training which mechanical engineering students receive in four-year courses?"

Nearly all reply that they are in general satisfied but that they feel that there is considerable room for improvement.

One executive writes "A four-year course is enough. The average young graduate just out is very raw material anyway. It takes about two years to make him worth his pay, except in rare instances."

The following paragraph from another letter expresses well the comment of a number of employers: "We are not completely satisfied with the training which mechanical engineering students receive in four-year courses in all engineering colleges. We feel

that more effort should be given to the study of fundamentals of science and engineering rather than so much specialization as is found in some schools."

Question No. 9.—"In what way do you believe that four-year courses in mechanical engineering may be improved?"

A number suggest the elimination of specialized courses and concentration on fundamentals.

A large percentage of replies included the suggestion that all engineering students receive instruction in the fundamentals of business organization and administration.

Quite a few would like to see more instruction tending to make the younger engineer "cost-minded."

Several feel that some attention should be devoted to instruction in salesmanship as applied to engineering.

A number believe that more emphasis should be placed on practical shop work, especially for young engineers who intend to enter production work.

Question No. 10.—"Additional Comment."

"We are becoming increasingly impressed with the value of 'General' engineering training. We are convinced that a fairly broad course, supplemented by special study, during employment, meets our requirements satisfactorily."

"We have had just as much and probably better success with young men who have had a regular scientific course or even an academic education."

"Our further comment is to bring attention to the attitude of a great many engineering graduates toward work on the drafting board. Almost without exception they resist this type of work which we consider essential for the first year to acquaint them with the details of our engineering problems."

"Faculty members should be encouraged to spend at least one out of every four summers in industry. Students should be required to have at least one summer of industrial experience prior to the senior year."

"It is our feeling that the average mechanical engineer is not very well grounded technically. My own belief is that this is largely because of the large number of specialized subjects given in the average mechanical engineering course, so that if I can make

any suggestions they would be that you stiffen up on your requirements in mathematics and mechanics and drop some of the specialized courses and add a little more of the cultural subjects."

"I would rather employ an engineer who barely squeezed through his course for four years but who had left the campus with a host of friends and a string of titles indicating that he was potentially a valuable leader of men."

"We get better results by employing young men from coöperative courses. This applies more particularly to our designing and production work."

DISCUSSION ON PRESENT USAGE OF SOPHOMORE COMPREHENSIVE EXAMINATIONS *

By G. B. THOM

Department of Mechanical Engineering, Swarthmore College

The purpose of this presentation is to bring before the members of the S. P. E. E. the results of a questionnaire bearing on the extent to which comprehensive examinations are in use at present in engineering colleges. This questionnaire was distributed during the spring of 1937, a copy being sent to each of the institutional members in the United States, as listed in the year book of the Society, and to each of the remaining engineering colleges in the United States, in so far as these could be ascertained from membership of individuals. In all, 182 queries were sent out, of which approximately 80 per cent were returned.

In answer to the question concerning usage of a comprehensive examination at the end of the sophomore year covering the work of the first two years, eight responded in the affirmative, these being Fenn College, Newark College of Engineering, Lehigh University, California Institute of Technology, Montana State College, University of Akron, James Milliken University, and the University of Maine. In addition, Massachusetts Institute of Technology gives a comprehensive examination to all electrical engineers in the junior year. A large number indicated rather extensive use of tests of this type during the freshman year. However, these results are not included in this report, since it is felt that this phase was adequately covered in the report of the Committee on Comprehensive Examinations presented last June and since published in the JOURNAL.

The subject matter covered in the sophomore comprehensive examinations in general includes the mathematics, physics and chemistry of the first two years. One college includes, in addition, materials, drawing and descriptive geometry; another, English and languages; another, English and history and omits chemistry. Two colleges report using the examination in only one subject matter field each, namely, one in mathematics and one in physics.

In most cases results of the examination are used with grades in course to determine fitness for advanced study in engineering, although here again diversity exists. In one case, results are used

* Presented at the 45th Annual Meeting, S. P. E. E., Cambridge, Mass., June 28–July 2, 1937.

purely in an advisory manner, a recommendation being made to student and parents for continuance or discontinuance in engineering. Other reported uses include improvement of teaching method, comparison, and as a basis for further study of the institution's needs.

The time allowed for the examinations varies widely among institutions, with an average being a little less than five hours. The times reported and the number of students involved are as follows:

Number of Institutions	Time Allowed	Approximate Total Number Students Involved
1	50 minutes (physics only)	50
1	2 hours (math. only)	50
1	3 hours	200
1	5 hours	100
2	6 hours	500
1	9 hours	150
1	2 days (probably 12 hours)	83

Regarding the type of examination employed, two institutions report making use of the Coöperative Test Service tests, one in mathematics and the other in physics. The remaining six colleges indicate use of examinations made by their respective staffs. Most colleges used the same type last year except one which used no comprehensive examination last year and is using the Coöperative Test for the first time, and one other which employs comprehensive examinations only on alternate years. A third institution is using its own examination this year for the first time. It thus appears that the trend is toward "home made" examinations since these can best be adapted to individual conditions.

Regarding future usage of comprehensive examinations in colleges not at present employing this educational tool, 4 institutions indicate plans to use them next year, 3 are uncertain regarding next year's policy in this respect, 9 are giving the matter serious consideration for the rather immediate future, and 24 have the matter under consideration but are not yet ready to venture an opinion. Finally, of the institutions that have used this type of examination in the past, only one has discontinued its use. In this case Coöperative Testing Service tests were employed for three years. The reason given for abolition was that no advantage could be seen due to variations in preparatory programs of the students involved.

Conclusions

Several rather definite conclusions may be drawn as a result of this survey. These are:

1. There has been a modest but definite increase in the use of

a comprehensive examination covering the work of the first two years in engineering.

2. Examinations of this type are finding increased favor among educators.

3. Due to the diversity of educational program among engineering colleges and to the recency of origin of the plan, examinations developed by its own staff are in general use in institutions employing this technique. However, there is a rather persistent demand for thoroughly standardized tests of this type.

And now I would like to philosophize just a bit about comprehensive examinations in general. In so doing I realize that I am commenting to three groups of individuals: first, those who are inclined to treat the matter as a panacea for existing ills; secondly, those who consider this type of examination a fad or passing fancy; and, finally, those attempting to evaluate the technique for what it is worth. My remarks are addressed primarily to the last group.

It seems to me to be highly desirable to introduce into our engineering teaching the concept that each subject matter field is not an entity in itself but that each of the applied fields of engineering is based definitely and fundamentally upon the basic sciences of chemistry, physics and mathematics. This is so evident that it perhaps requires no comment, but it has been my experience that in many cases students enter upon advanced undergraduate work without a sufficient realization of the interconnections that exist between the basic sciences and their significance in the program of professional development. An enforced review of these so-called "service" subjects at a time when the student is nearing completion of his study of them, it seems, will give him the opportunity to integrate and coördinate this background preparation. A comprehensive examination at this time constitutes one good means whereby the student can give evidence of his mastery of the material. Some may feel that this is but another examination covering the same ground, but it is only that if deliberately made so. There is ample opportunity to form questions in such a manner as to reduce memorizing ability to a minimum and to stress in its place real understanding of the fundamentals. If this natural division between preparatory and professional courses occurs during the sophomore year, the end of this year appears to be the logical time to introduce an examination of the type here discussed, if it be felt that this is the best means of evaluating the problem.

Small colleges and small departments of engineering are fairly unanimous in the thought that the technique of a comprehensive examination at some time between freshman and senior years is not necessary, since a greater intimacy exists between faculty and students, as a result of which more accurate appraisal can be made.

While there is no doubt considerable truth in this hypothesis, can the same be said of our larger colleges? Again, admitting the statement, do we not often find that a student who has done fairly well in a course, as exhibited by his grade, has an almost complete inability to coördinate and utilize the information he has assembled to date, when it must be applied to a problem not previously evaluated? Truly does this not represent accumulation of knowledge without the development of understanding? To meet the contingency, particularly in the larger colleges, the comprehensive examination appears to be a worthwhile expedient, since the time required to give the examination and to evaluate the results is relatively small.

Another point in its favor is the fact that reports made public by such institutions as the University of Maine and Lehigh University indicate that their tests incorporate high validity and reliability. This is particularly significant when one considers the state of the art at present and admits that much pioneer work has had to be done.

Professor Carvin of the Newark College of Engineering at an earlier session has suggested that the work of the first two years be treated as preparatory to the more or less professional subjects of the last two years, and has proposed that unqualified students be eliminated at the end of this probationary period. The same thought has been expressed frequently during the past by other educators. To-day, at least a few of our educational institutions provide, through the medium of a certificate of work completed, for a graceful withdrawal of those who do not show promise of satisfactory development in engineering. Is the sophomore comprehensive examination not an expedient vehicle for carrying on the process in those institutions in which it fits the educational program?

Throughout the sessions of the past few days there has recurred repeatedly the plea for a better coördination between the various contributing departments of the engineering curricula. The need for such coöperation is evident to all if a high type of educational advancement and the equally desirable integration of subject matter fields is to be achieved. Thus I say that perhaps one of the greatest benefits arising from the use of examinations of the type under discussion lies in the possibility of promoting the finest type of coördination between departments, not only between the professional and the pre-professional divisions, but also between individual members of each. This is particularly true in cases where the comprehensive examination is developed by the staff of the institution in which it is to be used. It is difficult for one who has not had this experience to realize its potentialities.

UNIT PROCESSES IN ORGANIC TECHNOLOGY*

By R. NORRIS SHREVE

Professor of Chemical Engineering, Purdue University

The field covered by the applications of organic chemistry to industry has an exceedingly wide and varied content. An ever-increasing number of such chemicals, useful in our technical life, are being made. Laboratory curiosities of yesterday are the tank car shipments of to-day!

Many of the young men whom it is our function to train, are going out to take their part in this work—some in research and development of new procedures or in building new equipment, many to operate the plants and still others to sell the products in manifold channels of trade.

In training these young chemical engineers there is needed the very best system of classification of the numerous facts and principles available, and, furthermore, there is required such a system that the common, or unitary, principles can be emphasized and the quantitative aspects presented. It is felt that such a classification is available for the chemical phases in what many are calling unit processes, in distinction from unit operations for the physical changes.

The study of unit processes is not new. Our pioneering colleague, Professor Harry McCormack, has been doing excellent work in these for many years at the Armour Institute of Technology. However, a number of us thought it wise to lay more stress on these as excellent tools in instruction and also as an improved means of viewing industrial procedures.

Since 1930 at Purdue University (Shreve, *J. Chem. Ed.*, **10**, 181–184 (1933)) we have been presenting organic technology, as we call it, classified under unit processes such as nitration, sulfonation, hydrogenation, chlorination, amination, ammonolysis, polymerization, hydrolysis, and the like. This is a very natural classification and one frequently met with in industry. For example, the apparatus and the procedures for carrying out hundreds of different diazotizations and couplings are almost invariably grouped together in the same structure. Indeed this is called the "azo building" after the products made. Similarly is this true for nitrations and reductions, where, under the same roof, may be found the appa-

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ratus for making from benzene, toluene, or xylene, or chlorobenzene, such products as nitro-benzene, nitro-toluene, nitro-chlorobenzene, dinitro-benzene, denitro-toluene and their reduction products as aniline, toluidines, m-phenylenediamine, m-tolylenediamines, chloro-anilines, and the like.

If the market warrants, a given sequence of unit processes to make certain products, such as phenol, is carried out month after month in the same apparatus. This latter is naturally the preferred procedure. But in these days of capitally-minded executives, the plant manager is required to keep his apparatus in almost continuous use, and if he has a stock of nitro-toluenes, he will use the same equipment for nitration of another chemical, as chlorobenzene.

There will not be found, of course, exact duplicate procedures for all nitrations in a given nitrator. But many of them will employ the same nitrating agent, such as mixed nitric sulfuric acid with the attendant auxiliary equipment, and most of them will involve the same large exothermic energy changes—with the necessary requirement for the removal of this energy as the reaction proceeds.

In another factory one will meet with esterifications, carried out in apparatus and conditions closely related for the manufacture of numerous different esters, each one involving a considerable similarity of procedure, such as means for removal of the water formed in the unit process of esterification. In the factories, one chemical engineer will become a nitration expert, or another one a hydrogenation specialist.

We could go on and multiply examples of these unitary aspects of the various unit processes, such as just cited. These unitary features are more in evidence in plant design now than was formerly the case. It has seemed that the further study of the unit process way of looking at chemical changes will enable us to better instruct our students in the following aspects of industrial operations:

(*a*) Increasing of yields due to a more fundamental understanding of the chemical changes.

(*b*) More continuous use of apparatus with the lessening of capital charge per pound of goods produced.

(*c*) A closer tie-in with the vital unit operations with consequent saving in power, steam, water, labor, and the like.

(*d*) A more generalized recognition of the proper design of chemical apparatus. Here, for instance, questions of corrosion can well be presented, such as the avoidance of any copper in construction of apparatus for ammonolysis, or not to use cast iron for measuring pots to hold mixed acid in nitrations.

(*e*) Some broad generalizations in equipment can be emphasized, as the close similarity between apparatus for some low energy change nitrations and most all sulfonations. (Shreve, ***Ind. Eng. Chem.*, 24,** 1344–1353 (1932).)

It is not necessary to divide organic procedures into aliphatic and aromatic divisions and thus treat esterification of phthalic acid and of acetic acid separately. They fall quite naturally under esterification where their unitary features become apparent. The writer at one time made this traditional separation, but has found by actual trial that it is unnecessary and confusing.

Before our students enter on unit process courses they have had physical chemistry. They have also had instruction covering the process industries in both the inorganic and organic field, wherein the procedures are taught involved in such industries as paper, acids, alkalies, sugar, manufacture of fertilizers, rubber, etc. It is also advantageous for the students to have had unit operations, or to be taking these courses.

Under unit processes are included the chemistry involved, the equipment necessary to carry on the reaction and the best means of making this equipment function properly, the energy changes, the various phases of cost of operations, the labor required, or any other special phases that may be pertinent to the actual plant manufacture of a given product. Finally, of course, there is a close tie-in with unit operations; indeed unit processes involve the application of the principles of unit operations.

The writer, when he started presenting this subject, was appalled by the multiplicity of procedures. In the initial presentation it seemed convenient to classify all these multitudinous operations according to reaction, or as we now express it, unit process. Seven years of experience have demonstrated that by so classifying this mass of material a very definite amount of unitary framework can be erected to hold together a lot of otherwise separate and distinct operations. Because of this classification, and the emphasis upon the common factors, it has been particularly easier to instruct the students in the broader phases.

We have at Purdue, as is true of other institutions, adopted a somewhat similar procedure as the Case System,—used so successfully in teaching law. These "cases" are found in the form of flow sheets of a given operation wherein we start with raw materials, carrying them through the requisite apparatus under the direction of labor, with the addition or removal of the necessary energy to form a given product or products, with or without by-products. Like in the teaching of law by the use of cases, many of these flow sheets are quite interesting in themselves, but they are

liable to stand up like individual trees in a forest among which the student is apt to get confused and then lost. On the other hand, by the classification of these various flow sheets under the heading of unit processes, order is at once apparent and the correlation of one flow sheet with another is strikingly brought forward. Likewise a great deal of time is saved, due to the similarity of certain phases of the individual flow sheets, so that when considering it under a given unitary head or process, much of the material regarding apparatus or procedure or chemical conditions need not be repeated.

There is no question but that the common, or unitary, phases of the unit processes have not been brought out as strongly as they should be. Particularly the investigation of many of the chemical changes has not been carried to the point where the principles involved can be definitely stated. It is to be hoped that future research will endeavor to make the path of the instructor simpler by paying more attention to the quantitative and unitary aspects. We need more common and related principles. It can be pointed out to the students of nitration that a great deal of heat is given out and that water is split off by virtue of the chemical reaction. These two phases, just for example, will enable the instructor to group these nitrations and to show why we use mixed acid as a rule in both absorbing the water and some of the heat, and why it is necessary to have efficient cooling to remove the absorbed heat as quickly as possible from the entire reaction. The excellent study of the Friedel & Crafts unit process by Groggins and his co-workers is an example of what we would like for the rest. But even for the Friedel & Crafts reaction we do not have as quantitative an expression as we could wish.

While all these unitary processes are very helpful in the lecture room, they are even more important in the laboratory, and by grouping similar reactions much time can be saved for the student in learning how such things go on. Pertinent observations as to the conducting of such experiments have been made by McCormack in *Chem. Met. Eng.*, **42**, 73–75 (1935) particularly under his heading "Process Experiments." It is usually only necessary to make specific experiments with typical reductions, or halogenations, or alkylations, to so thoroughly impress on the students' minds the general unitary principles involved, that the lecture room presentation of this subject with individual variations can be made more vividly.

While we have here considered unit processes as applied to organic chemical changes, there is no reason why a similar classification should not be used for inorganic chemical changes. Thus the making of sulfuric acid could come under oxidation and hydration.

A number have asked the question, "Why cannot all chemical changes be grouped under the unit operations, such as flow of heat, flow of material, or the like?" In the first place, this would remove the advantageous correlation between the actual plant practice of grouping like chemical changes together. In the second place the main object of the changes involved is not to introduce a given amount of energy, but too add a nitro group, or to react an acid and an alcohol to make an ester, or to polymerize and condense reactive groups to a resin. It is the nitro compounds, or the esters, or the resins that are the objects of the procedures; they are the products to be sold.

The greatest advantage the student gets from the unit process presentation is to have his attention attracted away from individual to group performances. He thus learns principles by going from the specific to the general, and while he may not in his actual practice use any one of the individual flow sheets employed to illustrate the unit process, he yet has the generalized viewpoint which will enable him to apply the fundamental unitary methods for making a new chemical that he has never met with before. It is the same type of generalization that helps the lawyer or judge in using past cases to decide a new one.

The field of organic technology is becoming more and more complicated. The classification by unit processes brings into this field the best system we have yet had, and enables a new flow sheet or a new apparatus to fit into its proper sequence.

Finally, we may point out that in chemical industry the reduction of manufacturing costs is constantly before the directing personnel. While there are many factors entering into the decrease of cost of chemical operations, the increase of chemical yields is an important, and in many of the more complicated procedures, the *most* important factor. So we may say that the study of these chemical phases as emphasized in unit processes cannot but act to decrease costs and thus widen the service that chemical industry renders to the nation.

BREADTH IN ENGINEERING CURRICULA *

By PHILIP C. NASH
President, University of Toledo

Last October, President Roosevelt asked the engineering profession to consider "whether the curricula of engineering schools are so balanced as to give coming generations of engineers the vision and flexible technical capacity necessary to meet the full range of engineering responsibility."

This is certainly a fair question and is entitled to the most serious consideration, but it appears to have made but little stir in the thinking of engineering administrators. Among others, President Compton of the Massachusetts Institute of Technology, Dean Potter of Purdue, President Williams of Lehigh, and Dr. Hammond, President of the Society for the Promotion of Engineering Education, all sprang to the defense of the engineering educator and replied in public letters to the President that everything is all right from this point of view—that the "engineering educators of the country are fully appreciative of the responsibility of the engineer in bringing about a better balance" †—that "during the past dozen years engineering educators have given extended attention to the problem of the development of social and economic elements in the education of engineering students." ‡

In other words, "We have the matter well in hand Mr. President, have had, in fact, for the last decade. Don't worry, we are training our students exactly as they ought to be, and by the way, why do you pick on us, anyhow? Why do you not ask the economists and lawyers and sociologists what's the matter with their training?" There the matter has rested for six months, we engineering educators having simply shrugged our shoulders indicating our belief that we are pretty nearly perfect as we are. But I wonder if it will hurt our dignity if we look a bit below the surface and see just what advances we actually have made in the last decade, how much we have really put into practice the lip service we pronounce in favor of broadening the engineering curriculum.

The self-examination of engineering education in this country undertaken by the Society for the Promotion of Engineering Education took place in the years 1923–29. It was a thorough-going and masterly piece of work and engineers may well be proud of it.

* Presented before the Ohio Section, S. P. E. E., April 17, 1937.
† Potter, *New York Times*, October 25, 1936.
‡ Hammond, *Letter to President.*

Certain facts that were brought out give food for thought. For instance, out of 76 institutions studied, 21 required more than 160 semester hours of work in the usual four year engineering course and the average for all the institutions was 147.* The normal requirement for the ordinary non-engineering college graduate was 120 semester hours.

Evidently we believe that by crowding numbers of courses on to our engineering students we shall make them better men. To some extent this is undoubtedly true. The engineering student is probably more serious than his liberal arts brother, ready to work more and play less, but it is permissible to wonder if the crowding into this time of 160 hours, one third more than we think wise for other students, may possibly leave our engineering student too little time for contemplation, for building up for himself a philosophy of society in general, and his own life in particular? Is such a student in after life just a bit too quick to build a safe, economical dam for his power plant without giving due consideration to those habits of the farmers who live 40 miles upstream and whose lack of soil conservation knowledge results in silting up one quarter of the nice new reservoir within a few years? How much does that constant pressure of daily tasks in difficult engineering and mathematical subjects go to produce a philosophy like that of the Rust brothers, the inventors of the new cotton picking machine? "What makes the Rust brothers' enterprise one of the most fascinating phenomena of our time is that they realize that if their machine is successful it will create profound social problems, and they want to be free to use the profits of the enterprise to assist in attacking these problems."†

But assuming that the engineering student is not too heavily burdened with work the next question is: shall he be allowed to come into official contact during his four year course with any subjects outside of physics, mathematics, and engineering, and if so, how much? Here again the investigation showed amazingly variable practices among the engineering schools but on the average about 17 per cent of the curriculum was found to be outside of engineering, mathematics, and physics. That is, 17 per cent consists of courses in literature and the arts.‡ In some cases it was much less than that. One institution required only one course in English. Everything else could be mathematics, physics, and engineering. Another institution was similar, substituting economics for English, and adding military training. Of course it was *possible* in these institutions and in most others to take courses in other fields, but the young students eager to acquire technical knowledge

* *Report of the Investigation of Engineering Education*, Vol. 1, page 485.
† *Harpers Magazine*, September, 1936, page 391.
‡ *Ibid.*, page 434.

as quickly as possible so as to have the advantage in getting an immediately better job, can hardly be expected to spurn the advanced electrical course in favor of aesthetics or history, or even accounting or statistics.

The leaders of this research had some doubts as to the wisdom of such a narrow curriculum. The distinguished director of the investigation, Dr. Wickenden, President of the Case School of Applied Science, said:

> "Young engineers in 3 cases out of 4 begin their careers in the realm of technical duties, but by the age of 40, 3 out of 5 are occupied with administrative duties." *

The committee sent out many questionnaires with interesting results. Nearly 60 per cent of a group of 4,000 recent graduates indicated their belief that cultural studies were either of considerable value or indispensable, compared with 40 per cent who varied their estimate of value from "worth the time spent" to "negligible." †

Fifty-one per cent said that economic subjects were regrettable omissions from their college courses and 26 per cent indicated the lack of English courses as similarly unfortunate.‡

The committee, rather sadly, I think, came to this conclusion: "It is quite clear that the engineers are more strongly in favor of extended training in economics and its application than are the teachers." § It is perhaps too much to expect that faculty members teaching engineering subjects should grant that time is well spent if it is taken away from engineering subjects and given over to more general problems.

The committee analyzed and summarized the opinions of nearly 8,000 carefully picked engineers as favoring the following principles.

1. Moderate diversity of curricula, but tending away from specialization.
2. Dominance of scientific and broadly technical content.
3. Inclusion of a well-identified core of required subject matter in common.
4. Inclusion at all stages of subjects of purely cultural value.
5. Due emphasis on the economic aspects of engineering and on its concern with administration and management.
6. Coherence of arrangement and coördination with related subjects.
7. Thoroughness rather than completeness of detail.||

* *Ibid.*, Vol. 2, page 1060.
† *Ibid.*, Vol. 1, page 241.
‡ *Ibid.*, Vol. 1, page 207.
§ *Ibid.*, Vol. 1, page 401.
|| *Ibid.*, Vol. 2, page 1248.

Certainly no philosophical student of education can hesitate to agree with this outline. Would not President Roosevelt himself find this a well balanced statement of the objectives of engineering education—hinting at the sociological import of the engineer's work even if it does not boldly emphasize it?

The important question of course is: How far are we carrying out these recommendations in actual practice? Are we paying lip service to "inclusion at all stages of subjects of cultural value" and "due emphasis on economic aspects" while at the same time saying "well in our case I guess about two 'non-engineering' courses will be sufficient, and that will leave a little more time for advanced machine design, or indeterminate structures, or electric communications?"

That the question is not yet quite satisfactorily answered is hinted not only in the President's Letter but in our periodical masterpiece, *Fortune*. Describing the dilemma of our leading engineering institution the writer says: "To take a seventeen year old boy, innocent of anything but high-school chemistry, physics, and algebra, put him through a four year mill, and turn him out making sense in a world full of entropy, thryatron tubes, three stage turbines . . . that is no small chore. Particularly is it no small chore when (*a*) some employers are constantly complaining that the Institute's eighteen different formal courses and twenty-odd option combinations still don't give them graduates with enough specializations; and (*b*) the Institute graduate in after life mourns that the Institute didn't give him enough broadening non-technical courses to make him able to appreciate the Good Life."*

The whole problem was approached again at the meeting of the Society for the Promotion of Engineering Education at Wisconsin. President Gaines took as the text of his address the quotation from James Bryce: "All education has two sides. It means to impart the knowledge, the skill, the habits of diligence and concentration which are needed to insure practical success. It also means to implant taste, to cultivate the imagination, and the emotions." Dean Kimball of Cornell spoke of the three great influences on character-learning, morals, and manners and quoted Plato for his definition of an educated man, and Dean Sackett of Pennsylvania State quoted Goethe and Emerson to clarify the character education which engineering instructors should attempt to give.

So everywhere are engineering educators proclaiming their adherence to the philosophy of a broad cultural foundation. What are they actually doing in curriculum revision to make this possible? We cannot be any too well delighted with the answer. I

* *Fortune*, November, 1936, page 132.

chose at random six engineering schools of high grade and studied their curricula in mechanical engineering, not with any view toward the writing of this paper, but to compare them with the new curriculum which we have just adopted at the University of Toledo.

The engineering schools studied were Brown, Case, Cornell, M. I. T., Worcester, Yale, and Toledo. I included mathematics, physics, chemistry, and engineering proper as engineering subjects. Everything else I called non-engineering, including English, economics, history, political science, "seminar," "reports," "introductory lecture," "trips," etc. Physical education, gymnasium, and military training were not counted at all. It is always dangerous to try to tell from a catalog exactly how a given curriculum is administered, but the following figures are probably not greatly in error.

At Brown	20 per cent of the curriculum is non-engineering.
At Case	16 per cent of the curriculum is non-engineering.
At Cornell	9 per cent of the curriculum is non-engineering.
At M. I. T.	15 per cent of the curriculum is non-engineering.
At Worcester	18 per cent of the curriculum is non-engineering.
At Yale	24 per cent of the curriculum is non-engineering.
At Toledo	21 per cent of the curriculum is non-engineering.

Leaving out Yale, Brown, and Toledo the average for the non-technical work at the other four schools of engineering is 15 per cent. In other words, these schools are taking high school boys of eighteen, giving them a very stiff four year course with only one-sixth of their attention given to anything outside professional work. No other profession such as law, medicine, teaching, or the ministry dreams of giving so narrow a preparation for life. Probably no chemist, journalist, or graduate of a school of business administration could get such a narrow education at any college in the country. Are we justified in giving it to engineers?

The pleas from the engineering educator are two: (1) We have to give as much engineering in four years as does our competing engineering school or all our students will go there. (2) Our graduates must have this advanced knowledge to get a job.

The second argument I think is specious. No matter how much we try to cram into a boy's head in four years we cannot make him an engineer. We can give him only the foundation; if he is to rise in his profession it will be only through long years of experience and study in his special field. How many engineering graduates are called upon to design important and complicated engineering structures when they first graduate? Not one in a thousand, I wager. Certainly, I, myself, had to serve an apprenticeship with checkers going over everything I turned out in the office, and

with assistant engineers over me to check decisions in the field. Has it not been thus with every young engineer? And if so, cannot we spare a little more time in his crowded curriculum to give him a chance to think about the other side of his life, even at the expense of a few hours stolen from advanced specialized courses in engineering?

A relatively small increase would make a great difference. If the average of the four lower schools mentioned, 15 per cent, were raised to that of the three higher schools, 22 per cent, the increase would be only 7 per cent. If that were done, it would to a considerable extent remove the engineering educator's plea number one, that of "keeping up with the Joneses."

It is my personal opinion that 22 per cent is too low, that 30 per cent would be better. Ten years after graduation I believe you would have stronger men in the engineering profession if about one-third of their time during those four college years were spent in subjects outside of engineering. I have seen many college graduates with even less than two-thirds of their time spent in engineering who can easily catch up with their more technical brethren and I find little objective evidence to support the theory that a competent engineer cannot build up his theoretical and technical knowledge after he leaves college. Of course, he can build up his economic and cultural knowledge also, but he can do it much better perhaps if he has had some real foundation for such work during his college course. So it seems to me that our own investigation, the plea of President Roosevelt, the speeches of our leading engineering educators all point to a little more liberal engineering curriculum. Are we going to do anything more than talk about it?

Of course, there is one easy solution that may be directly before us now that engineering schools can be accredited and engineers licensed. That is to follow the lead of the law profession and demand two years of liberal arts work before undertaking the study of engineering at all. If such a program were adopted the two years of preliminary work might be divided into approximately five courses each year, and out of the ten we could ask the liberal arts college to include two courses in mathematics, including calculus, one course in chemistry, one in physics, one in mechanical drawing. Then in each of the four years spent thereafter in the engineering school we could include one course outside the engineering field. Such subjects as economics, sociology, political science, æsthetics, psychology, and philosophy could find places in our programs and we might really carry out our mandate from the profession, "the inclusion at all stages of subjects of purely cultural value." Certain universities such as Columbia, Cornell, and Harvard are already tending in this direction; perhaps we may all soon follow.

PLAN FOR ORGANIZING A COURSE*

By R. W. SELVIDGE

Chairman, Department of Mechanical Engineering, University of Missouri

In the organization of subject-matter for teaching purposes we should apply our engineering procedures, rather than the traditional procedures of the professional educator. This involves a detailed analysis of the problem and a listing of the specific requirements. Our first question should be, "What are the specific things we expect the student to know and to be able to do when he has completed the course in a certain subject-matter field?" The answer to this is not an ordinary syllabus of what *the teacher expects to talk about* but a definite list of what *the student is expected to learn* and what the teacher will assist him in mastering.

Such a plan changes the point of emphasis by placing directly on the student the responsibility for learning, with the assistance of the teacher, rather than placing the responsibility on the teacher for teaching the student whether he accepts the responsibilities for learning or not. With such definite objectives and responsibilities before him the student will work more earnestly and can, in a large measure, determine his own achievement.

It is not a plan to eliminate the textbook but a plan to make it more useful. It also offers the most effective means of selecting a text. If you have a list of the specific things you wish the student to learn it is rather a simple matter to examine a number of textbooks and determine which of the topics they treat and whether the treatment is adequate and understandable.

There is not sufficient time to discuss the general principles involved in such a procedure and, with only a hint at its values, I submit a suggested plan of procedure and sufficient illustrative material to show how the plan of organization is applied.

General Plan for Organizing a Classroom Subject

I. *Selecting the Subject-Matter*

Make a list of the teaching or learning units which you expect the student to know at the end of the course.

This will be a list of the important topics or ideas around which may be grouped related ideas of lesser importance. They should be stated very briefly and definitely.

The units will vary in length or amount of material to be presented and probably will not correspond to class periods. In

* Presented at Meeting, Missouri Section S. P. E. E., Rolla, April 10, 1937.

general the beginning units should be short; the later ones may be somewhat longer. The limits are subject to wide variation but there should be a feeling of some unity or completeness in the topic.

The list should be regarded as subject to modification or extension at any time.

The student should be provided with a copy of the list. To him it should be a list of the things he is expected to learn; to the teacher it should be a list of the things he expects to teach.

II. *Organizing the Subject-Matter*

Prepare the material for each unit as a definite written assignment.

The assignment may deal with factual material, principles or problems. The essential features of it should be, in general, about as follows:

1. A statement of the topic, and of the requirement, in such a definite way that the student can have no doubt as to what is required.

2. This should be followed with two or three short paragraphs intended to suggest procedures, direct the thought of the student, or to give some suggestion or information which will be helpful in the solution of the problem or in understanding the principle.

3. Give specific page reference in texts or in some *available* source. When more than one reference is given they should be placed in order of importance and availability if possible.

4. Give illustrations or examples of the application of the principles in order that they may be thoroughly understood. These should be sufficient in number to illustrate the more difficult phases of the unit.

5. Give questions to direct reading or thought, and problems to give application of the principles.

III. *Presenting the Subject-Matter*

1. *Give out assignments and require written reports.*

These should be submitted at the meeting proceding the meeting at which the topic is to be discussed in order that the teacher may determine whether there is a common difficulty and what phases of the topic should be discussed and by whom.

2. *Class discussion of assignments and reports.*

This gives an opportunity to extend and clarify the ideas of students and show new applications and get a check on whether a student is doing his own work.

3. *Tests covering the assignments.*

Frequent short written tests and oral quizzes should be given to establish a recognition of the importance of individual learning and individual responsibility and to determine the achievement of individual students.

The purpose of the assignment is to place on each student a definite, fixed, and inescapable responsibility and provide him with all the means necessary for the solution of his problem. It is essential that each assignment be made very complete. The class meeting will serve to check the student on his understanding of the problem, and reveal any faults which may appear in the assignment.

(The following is an example of a list containing a few of the learning units in an elementary course in heat engineering. A complete list should be given to the student.)

Heat Engineering

This is a list of the things you are expected to learn in this course. You will be expected to know them thoroughly, not only as facts but to know how to use them as tools in the solution of engineering problems. You will be tested frequently on your knowledge of these things and your ability to apply them.

1. Important definitions.
   Work, force, power, energy, efficiency, mass, matter.
2. The fundamental units of measurement.
3. The types of energy and the characteristics of each.
4. The kinetic theory of heat.
5. The law of conservation of energy.
6. Relation of heat to work.
7. The first law of thermodynamics.
8. The scales for measuring temperature.
9. The devices for measuring temperature.
10. Boyle's or Mariotte's Law or the law of the relationship between the temperature, volume and pressure of a constant mass of any gas.
11. The Law of Charles and Gay-Lussac, or the law of the expansion of gases.
12. The equation of State.
13. The Perfect Gas.
14. Avogadro's Law, or the relation between temperature and pressure and the number of molecules per unit of volume of any gas.
15. Dalton's Law: Every gas appears to be a vacuum for every other gas.
16. The standard heat unit, B.T.U.
17. Specific heat.
18. Distinction between heat and temperature.

This list should be continued to cover the other principle learning units in the course.

(Example of the organization of one of the Learning Units. This is to be given to the students as an assignment.)

Assignment X

Boyle's Law

Boyle's Law is a statement of the relationship between the temperature, volume and pressure of a constant mass of any gas.

Information

The cardinal properties of a substance are those which can be determined by immediate examination. They are properties which fix the present state or condition of the substance.

The cardinal properties of *perfect gases* are very important because they are so related, mathematically, that if the value of any two properties for a given condition are known all the others may be readily computed.

The following are the Cardinal Properties of Gases and their symbols:

Cardinal Properties		*Symbols*
Pressure	=	P
Volume	=	V
Temperature	=	T
Entropy	=	N
Internal Energy	=	E_i

These cardinal properties, represented by their symbols, are used in all computations with respect to gases You should have a clear understanding of the meaning or significance of each.

Boyle's Law is a statement of the relationship between the temperature, volume, and pressure of a constant mass of any gas. It is also referred to at times as Mariotte's Law because each discovered it, working independently. It concerns the action of gases under certain conditions. It may be stated briefly as follows:

"At a constant temperature, the volumes of a constant mass of any gas are inversely proportional to the pressures."

This is a very important law and you must not only know the words but you must understand the various relations expressed. You will have much use for it.

We will now use the symbols of the cardinal properties of gases to state Boyle's Law in the form of equations.

1. $V \backsim \frac{1}{P}$ (Temperature constant)

or we have this,

2. $V = \frac{C}{P}$ which is read: The volume is equal to the constant divided by the pressure.

Thus

3. $PV = C$, also $P_1V_1 = P_2V_2 = C$

The symbols without the subscript refer to quantities in general and those with subscripts refer to particular conditions. The following may be stated also $V = M_v$ where M represents the weight or the mass of the gas under consideration and v the specific volume, or volume in cubic feet of one pound of gas.

The relations are true for any system of units as long as they are used consistently. For example, the pressure of one standard atmosphere is 2116.2 pounds per square foot and the volume of 1 pound of air, at 32° F. and the pressure of one standard atmosphere, is 12.39 cubic feet. Substituting these values we have

$$PaVa = 2116.2 \times 12.39 = 26{,}220.$$

References:

Cross, Chas. N., "Heat Engines," pp. 37–39.

Severns and Degler, "Steam, Air and Gas Power," pp. 11–12.

Questions:

1. What is meant by pressure?
2. What is meant by specific volume?
3. What is the distinction between temperature and heat?
4. What is meant by weight?
5. What is the difference between weight and pressure?
6. What scale do we use for measuring pressure?
7. What scales do we use for measuring temperature?
8. What units are used in measuring volume?
9. Give a short statement concerning Boyle and his work.
10. Give a short statement concerning Mariotte and his work.

(Give eight or ten problems requiring a statement of the equation and the solution.)

Plans for Organizing a Laboratory Subject

Laboratory work has become a fixed and valuable part of engineering instruction but the purposes for which it is most effectively used are not always kept in mind.

I. *The General Purposes of Laboratory Work*

1. To teach students how to use certain types of engineering instruments and equipment.

2. To teach students the procedures in performing certain engineering tasks of *operation.*

3. To teach students methods of procedure in performing engineering tasks, of *observation, investigation,* and the recording of data.

4. To apply approved methods to the interpretation of data.

5. To demonstrate the application of certain principles in order that they may be more clearly understood.

6. To discover new facts or relationships.

In organizing our laboratory subjects we should list in units those things which we believe may be most readily learned through laboratory experiences. We should then design experiments, to teach them. Such a list of the specific things we wish to teach is prerequisite to a wise and economical selection of laboratory equipment.

The essential features for the organization of laboratory work are about as follows:

II. *Selecting the Subject-Matter*

1. *Prepare a list of the things you expect the student to learn through his experiences in the laboratory.*

This is not a list of *experiments* but a list of things some of which may be involved in a number of experiments.

III. *Organizing the Subject-Matter*

1. *Prepare a list of experiments.*

Each experiment, before it is approved for use, should be analyzed to determine which of the things the student is expected to learn are contained in the experiment. By this method it is easy to determine whether the experiments cover the field adequately and whether some units are neglected. It may be found that some of the units may be taught more economically in the classroom than laboratory.

When an experiment has been selected it should be followed by a statement indicating the significance and general purpose together with a list of the things the student is expected to learn by the experiment.

A chart giving the learning units and showing the ones which are involved in each experiment is a very effective way of presenting this. (A sample chart is attached.)

2. *The assignment.*

Each laboratory assignment is based upon a selected experiment and should consist of:

a. The name of the experiment.

b. The list of the things the student is expected to learn from performing the experiment.

c. General directions or cautions, dealing mainly with personal safety and the care and use of equipment.

d. The requirement of a definite plan of procedure by student to be approved by the teacher before the work is started.

e. Questions to give direction to the experiment and to call attention to the significant facts which are to be developed.

f. Tests to determine whether the student has learned what he was told he would be expected to learn.

g. The requirement of a report.

We should assign men very definite tasks within their ability,

make available all the material necessary for the solution of the problem, and hold them to a strict accountability for each assignment. We believe they will like such definite statements of the requirements and that it will tend to develop in them a feeling of responsibility and self-reliance.

It is believed that a selection and organization of our subject-matter along the lines indicated will improve our teaching by revealing to the teacher just what is to be taught and to the student just what is to be learned. The teacher will be more exact in his preparation and more definite in his instruction. Much time will be saved.

SECTION OF ANALYSIS CHART. MECHANICAL LABORATORY

Things to be Learned	Experiments	Pressure Instruments	Temperature Instruments	Planimeters	Indicator Study and Calibration
1. How to write a report		1	1	1	1
2. How to plan the procedure in making an experiment		2	2	2	2
3. Importance of care in the handling and adjustment of instruments		3	3	3	3
4. Safety rules and safety attitudes in the laboratory		4		4	4
5. Degree of accuracy required in observations, measurements and calculations		5	5	5	5
6. Under what conditions are manometers used		6			
7. How to measure pressure with a manometer		7			
8. How the Bourdon steam gage operates		8			
9. How to calibrate the Bourdon steam gage with tester		9			
10. How to measure pressure with a Bourdon steam gage		10			
11. How to measure pressure with an aneroid barometer		11			
12. How to measure pressure with a mercury barometer		12			
13. The principal kinds of temperature measuring devices			13		
14. How the mercury and alcohol thermometers work and the conditions favorable to their use			14		
15. How the thermometer with a metallic element works and the conditions favorable to its use			15		
16. How the thermoelectric couple works and the conditions favorable to its use					
17. How the radiation pyrometer works and the conditions favorable to its use					
18. How the optical pyrometer works and the conditions favorable to its use					
19. How pyrometric cones work and conditions favorable to their use					
20. How to measure temperatures with a mercury thermometer					
21.					
22.					
23.					

NECROLOGY

Dr. Gardner Chase Anthony, a past President of the Society for the Promotion of Engineering Education, died on November 28, 1937, at 5 Circuit Road, New Rochelle, New York, at the age of eighty-one.

Dr. Anthony was born in Providence on April 24, 1856, son of David Chase and Sarah Carpenter Anthony. He received his early education at English and Classical School in Providence. Later he attended Brown University and Tufts College from 1875 to 1878 for special courses in engineering. Upon completion of the special courses at Tufts College in 1878, he practiced engineering for several years with the Brown and Sharpe Manufacturing Company of Providence, specializing in mechanical drawing and design. In 1893 he became dean of the Broomfield-Pearson School and professor of drawing. In 1896, he became director of the mechanical department of the Rhode Island School of Design. The following year he founded the Rhode Island Technical Drawing School of Providence. Later (1898) he returned to Tufts College and was made first dean of the newly formed Engineering School and continued in that capacity until his retirement as dean emeritus in 1927. From Tufts College he received an honorary master of arts degree in 1889 and an honorary doctor of science degree in 1905.

After his retirement he became associated with Principia College of St. Louis, Missouri, as a member of the board of trustees and chairman of the building committee. He was connected with the New York office of the college at his death.

Dr. Anthony was known widely in engineering circles but particularly in New England through his thirty-four years of unbroken service at Tufts College.

Dean Anthony was a recognized authority on several phases of engineering and engineering education. He was President of the Society for the Promotion of Engineering Education in 1913–14. He also was a member of the American Society of Mechanical Engineers and the American Association of Arts and Sciences.

Dean Anthony held a unique position in the early development of engineering graphics through the many works he published on mechanical drawing machine design and descriptive geometry. Those who have used his texts in the teaching of graphics fully appreciate the directness and thoroughness of his works.

All who attended the Session on Engineering Drawing and Descriptive Geometry at the Carnegie Institute of Technology in

Pittsburgh during the latter half of June 1930 will long remember Dean Anthony's genial and attractive personality. Those who have had the privilege of association with him have recognized his genuine qualities and as the years passed on found their affection for him steadily growing.

He leaves his widow, Mrs. Ella Taylor Anthony, whom he married in 1921 after the death of his first wife, and a son, Charles Pearson Anthony of New York.

F. W. MING

PROFESSOR JAMES A. CORRELL, Electrical Engineering Department, University of Texas, was born May 4, 1883, in Wayne County, Ohio. He attended the public schols in Manhattan, Kansas, and in 1899 entered the Kansas State Agricultural College, from which he received the degree of Bachelor of Science in Mechanical Engineering in 1903. After two years of experience in the operating field, he entered the Massachusetts Institute of Technology, where in 1907 he received the degree of Bachelor of Science in Electrical Engineering. He received the degree of Master of Science in Electrical Engineering at the University of Texas in 1925.

He became instructor in Electrical Engineering at the University of Texas in 1907, and remained continuously at that schol until his death on October 30, 1937. During his years of service at the University of Texas, he advanced through the grades of adjunct professor, associate professor, and full professor, finally becoming head of the Electrical Engineering Department in 1927. He was elected to the graduate faculty in 1930.

Professor Correll became an associate member of the American Institute of Electrical Engineering in 1908 and has continued through the grades of associate and member until his death. He was very active in promoting Institute affairs in the Seventh District, and was for many years counselor to the Student Branch at the University of Texas.

In 1936–1937 he was President of the Texas Section of the Society for the Promotion of Engineering Education. He also was a member of Eta Kappa Nu, honorary Electrical Engineering fraternity, of Phi Kappa Phi, of the University of Texas Science Club, of the Scholia Club, of the Austin Technical Association, of the A. F. and A. M., and of the University Methodist Church.

In collaboration with J. M. Bryant, he wrote "Alternating Current Circuits," published by McGraw-Hill, and since its original publication, has done much work in the production of revisions of that text.

NEW MEMBERS

Active institutional membership—University of Santa Clara.

Associate institutional membership: Fenn College, Lewis Institute, Los Angeles Junior College, Scranton-Keystone Junior College, Texas College of Arts and Industries.

Individual Membership

Allen, Russell B., Assistant Professor of Civil Engineering, University of Maryland, College Park, Md. S. S. Steinberg, G. C. Ernst.

Baker, Edwin M., Professor of Chemical Engineering, University of Michigan, Ann Arbor, Mich. H. H. Higbie, A. H. White.

Barber, William J., Assistant Professor of Mechanical Engineering, Villanova College, Villanova, Pa. J. S. Morehouse, H. S. Bueche.

Bartlett, Grady W., Instructor in Physics, North Carolina State College, Raleigh, N. C. W. H. Browne, C. R. Bramer.

Binney, John H., Professor of Mathematics, A. & M. College of Texas, College Station, Texas. N. F. Rode, M. C. Hughes.

Brattin, Claud L., Assistant Professor of Drawing and Design, Michigan State College, East Lansing, Mich. L. N. Field, H. B. Dirks.

Budd, Harold J., Assistant Professor of Law, Drexel Institute of Technology, Philadelphia, Pa. Dawson Dowell, R. C. Disque.

Dariaux, John B., Professor of Theoretical Physics, North Carolina State College, Raleigh, N. C. W. H. Browne, C. R. Bramer.

Evans, Henry P., Associate in Civil Engineering, University of Illinois, Urbana, Ill. W. C. Huntington, T. C. Shedd.

Gilchrist, Gibb, Dean of Engineering, A. & M. College of Texas, College Station Texas. F. C. Bolton, N. F. Rode.

Gray, Milton E., Engineer-in-Charge, Scientific Service, 4830 West 18th Street, Los Angeles, Calif. D. E. Whelan, J. de la Garrigue.

Grosvenor, A. W., Assistant Professor of Mechanical Engineering, Drexel Institute of Technology, Philadelphia, Pa. D. Dowell, W. J. Stevens.

Grandi, Louis L., Instructor in Electrical Engineering, A. &. M. College of Texas, College Station, Texas. N. F. Rode, M. C. Hughes.

Haenisch, Edward L., Assistant Professor of Chemistry and Chemical Engineering, Villanova College, Villanova, Pa. J. S. Morehouse, H. S. Bueche.

Haupt, Lewis M., Assistant Professor of Electrical Engineering, A. & M. College of Texas, College Station, Texas. N. F. Rode, M. C. Hughes.

Hedges, Charles C., Head, Dept., Chemistry and Chemical Engineering, A. & M. College of Texas, College Station, Texas. N. F. Rode, L. M. Haupt.

Hill, Clifton C., Assistant Professor of Applied Mechanics, Virginia Polytechnic Institute, Blacksburg, Va. J. B. Jones, J. I. Clower.

Holmes, Wilfred J., Assistant Professor of Engineering, University of Hawaii, Honolulu, T. H. R. C. Brinker, C. B. Andrews.

Hopper, John S., Instructor in Mechanical Engineering, A. & M. College of Texas, College Station, Texas. N. F. Rode, L. L. Fouraker.

Howell, E. J., Registrar, A. & M. College of Texas, College Station, Texas. F. C. Bolton, N. F. Rode.

Joffe, Joseph, Assistant Professor of Mechanics, Newark College of Engineering, Newark, N. J. P. E. Schweizer, J. H. Fithian.

KNIFFEN, ALLEN T., Instructor in Mechanical Engineering, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. J. A. Lambertine, E. F. Church.

KOENIG, LOUIS A., Assistant Professor of Chemistry and Chemical Engineering, A. & M. College of Texas, College Station, Texas. N. F. Rode, M. C. Hughes.

KRASE, NORMAN W., Associate Professor of Chemical Engineering, University of Pennsylvania, Philadelphia, Pa. W. A. Sloan, R. L. Spencer.

LABBERTON, JOHN M., Assistant Professor of Mechanical Engineering, New York University, New York City. D. B. Porter, A. C. Coonradt.

LAUER, BRYON E., Assistant Professor of Chemical Engineering, North Carolina State College, Raleigh, N. C. C. R. Bramer, E. E. Randolph.

LAWLER, LEO T., Assistant Professor of English, Carnegie Institute of Technology, Pittsburgh, Pa. R. E. Doherty, W. N. Jones.

MCKIBBEN, EUGENE G., Iowa State College, Ames, Iowa. L. O. Stewart, H. J. Gilkey.

MAHER, FRANCIS J., Instructor in Applied Mechanics, Virginia Polytechnic Institute, Blacksburg, Va. J. B. Jones, J. I. Clower.

MEARES, JEFFERSON S., Associate Professor of Physics, North Carolina State College, Raleigh, N. C. W. H. Browne, C. R. Bramer.

NAHIKIAN, HOWARD M., Instructor in Mathematics, North Carolina State College, Raleigh, N. C. J. W. Cell, H. A. Fisher.

NORRIS, CARROL B., Assistant Professor of Electrical Engineering, Tulane University, New Orleans, La. C. W. Ricker, J. M. Robert.

PALMER, STANLEY G., Professor of Electrical Engineering, University of Nevada, Reno, Nev. F. H. Sibley, J. A. Carpenter.

STEPHENS, EUGENE M., Assistant to Personnel Manager, Industrial Relations Dept., U. S. Steel Corp., 71 Broadway, New York City. E. A. Holbrook, H. P. Hammond.

STRATTON, LEON D., Professor of Chemistry; Dean of Men, Drexel Institute of Technology, Philadelphia, Pa. R. C. Disque, J. H. Billings.

TRIPP, WILSON, Instructor in Mechanical Engineering, Kansas State College, Manhattan, Kansas. Linn Helander, R. A. Seaton.

VANCE, HAROLD, Professor of Petroleum Engineering, A. & M. College of Texas, College Station, Texas. N. F. Rode, M. C. Hughes.

VIVIAN, ROBERT E., Associate Professor of Chemical Engineering, University of Southern California, Los Angeles, Calif. F. O. Rose, R. M. Fox.

WALTON, T. O., President, A. & M. College of Texas, College Station, Texas. F. C. Bolton, N. F. Rode.

WARD, HENRY T., Assistant Professor of Chemical Engineering, Drexel Institute of Technology, Philadelphia, Pa. W. J. Stevens, D. Dowell.

WARD, ROBERT P., Assistant Professor of Electrical Enginering, A. & M. College of Texas, College Station, Texas. Re-instatement.

WICKER, DAN B., Associate Professor of Chemical Engineering, North Carolina State College, Raleigh, N. C. E. E. Randolph, J. D. Lindsay.

WILCOX, DONALD B., Instructor in Mechanical Engineering, Georgia School of Technology, Atlanta, Ga. R. L. Sweigert, W. A. Hinton.

WILLIAMS, ED L., Professor and Head, Dept. of Industrial Education, A. & M. College of Texas, College Station, Texas. N. F. Rode, M. C. Hughes.

WILLIAMS, FRANK H. M., Associate Professor of Mathematics, Drexel Institute of Technology, Philadelphia, Pa. Dawson Dowell, W. J. Stevens.

YOUNG, HERBERT R., Associate Professor of English, Case School of Applied Science, Cleveland, Ohio. K. O. Thompson, W. E. Nedd.

180 new individual members + 6 institutional members

ENGINEERING ECONOMY PAGE

Engineering economy deals with comparisons between technical alternatives in which the differences between the alternatives are expressed as far as practicable in money terms.

EDMUND D. AYRES, University of Wisconsin, *Editor*

"When *I* use a word," Humpty Dumpty said, in rather a scornful tone, "it means just what I choose it to mean—neither more nor less."
"The question is," said Alice, "whether you *can* make words mean so many different things."
"The question is," said Humpty Dumpty, "which is to be master—that's all."
—Lewis Carroll in "Through the Looking Glass."

* * * * *

When I read the mimeographed letter referred to in the September Engineering Economy Page, I accused Professor Ayres of trying to be Humpty Dumpty. No doubt Alice was wrong; Humpty Dumpty or anyone else *can* make any word or phrase mean a great many different things. The real question with regard to "engineering economy" is whether it is advisable to do so—whether this phrase will not be more useful if its scope is restricted to its original meaning.

The term "engineering economy" was first suggested by the late Professor George F. Swain to correct a Humpty Dumpty situation which had arisen with regard to "engineering economics." This latter phrase had come to be used in a number of different meanings, with the resulting inevitable conclusion as to what it was intended to mean in any specific instance. "Engineering economy" was suggested to be used for one of those several meanings, *i.e.*, the "Will it pay?" aspects of engineering decisions. In pursuance of Professor Ayres' editorial policy of giving a different proposed definition each month for the next few months, my suggestion for a definition of engineering economy in this restricted sense is carried at the top of this page.

This definition is intended to imply that an engineering economy study is always for the purpose of guiding a decision—usually although not necessarily a business decision. The special characteristic of such a study which differentiates it from any other engineering study is the attempt to express dissimilar and otherwise incommensurable units in terms of a common standard of value, money. An acceptance of this definition implies, of course, that many matters referred to by Professor Ayres in the September and November Engineering Economy pages will be relevant in specific engineering economy studies; this does not mean, however, that these subjects are in any sense included in engineering economy, even though, as Professor Ayres points out, a course in this subject may serve as an educational threshold for many of them.

EUGENE L. GRANT

ENGLISH NOTES

DEVOTED TO THE INTERESTS OF TEACHERS
OF ENGLISH IN ENGINEERING SCHOOLS

J. L. VAUGHAN, *Editor*

A PLAN FOR REMEDIAL ENGLISH

One of the chief obligations of any college is, obviously, that of training undergraduates to write accurately and speak forcefully. Faculties of our colleges of engineering have only recently voiced the opinion that much of the success or failure of graduates depends upon their abilities in English and in their broad, cultural horizons. Toward these ends, a thorough knowledge of English Grammar is prerequisite. How, then, shall we make sure that we are meeting the obligation? Shall it be accomplished by stricter entrance requirements, by the formation of Sub-Freshman groups, or by regular courses of Remedial English in our engineering curricula?

I should like to outline a course which has been effective since its conception three years ago at the Case School of Applied Science, Cleveland. Undoubtedly it has its weaknesses, leaving much to be desired; nevertheless, the writer has evidence of positive gains made by students who have taken the course. Remedial English—known as English 31a, "English Grammar and Composition"—is given during the first term of the college year, is open to freshmen, and has equal credit value with all other courses. We feel that interest in the work is encouraged when embryo engineers see the emphasis placed upon it by its three graduation credits and by the fact that it parallels other freshman subjects.

Entrance requirements at Case are similar to those of other technical schools. Admission is restricted to approximately 250 men who bring proper certification from accredited high schools or academies, and who, generally, are in the upper two-thirds of their high school classes. The usual fifteen units are required, three of them in English.

After a new class has been enrolled, all are given aptitude and training tests in order to determine individual differences and probable tendencies. At the beginning of the second week, and on the basis of scores on the Iowa aptitude and training tests in English (which, by the way, we find relatively accurate), the Dean assigns

those of the lowest scores to one or more sections of Grammar. For the past three years, the class has numbered about twenty-two men a year. This fall, however, in two sections of such work there are thirty-seven freshmen out of a class of two hundred and eighty-six. The inference that only twelve per cent of the freshmen need Remedial English is far from accurate. The truth is that many more surprise us greatly by their general inadequacy in vocabulary, in spelling, in punctuation, and in correct construction.

Engineering faculties realize, of course, that men with interests leading to the choice of engineering as a profession are not much interested in English beyond the forms of daily conversation and meager reading. Many freshmen admit surprise in learning how important English in engineering really is. Somehow, in all innocence, they had assumed that only graduates prepared for other professions needed such fundamental training as we try to give. This assumption, happily, is immediately dispelled by contact with those members of the engineering departments who set rigorous standards for laboratory reports, letters, and research papers. The faculty as a whole, whether members of the department of English or of an engineering faculty, face a stimulating challenge in being entrusted with the development of a group of young men who will not be handicapped in later years. The instructor of classes in English Grammar faces just this problem in training correct habits of speech.

The method employed in these courses is as follows: To the end that the basic principles of sentence construction and punctuation be covered with some certainty, a good textbook is essential, one that presents clear and forceful explanations and provides interesting exercises for drill. I believe the instructor's efforts in emphasizing, clarifying, and stimulating, to be of more benefit than the selection of the proper handbook. Next, that students may develop a free-flowing, well-phrased style of expression, they submit themes once a week and book appreciations each month. In both, the instructor grades manner of expression more than quality of ideas. Revisions are required before final acceptance of the compositions. Topics for themes and suggestions for book reviews are furnished by the instructor. In this he prays for divine guidance. His selection must yield meaningful, suggestive ideas for composition.

To the end that students have individual drill sufficient to indicate the progress they are making, it is advisable to use some form of supplementary exercises as provided by all reputable publishing firms. I have used "A Writer's Manual and Workbook" by Paul P. Kies (F. S. Crofts and Co.), and intend to use "The Nelson

Practice Leaves" (Malcolm Mc-Leod-Thomas Nelson and Sons) this year.

In order to have the students appreciate the practical value of such studies, one issue of a magazine such as the *Atlantic Monthly* or *Scribners* is supplied by each student. We make inspection of various phases of writing and editing.

Finally, to give members of such classes opportunity to develop confidence, poise, and correctness of oral expression, a schedule of short talks is drawn up, and students are given complete freedom in choice of topics. The instructor requires an outline before the talk is presented.

With these several aims in view, therefore, and within a course of fifteen weeks, one hundred and fifty minutes per week, the Remedial English is completed, provided the student passes the course with a minimum grade of 60. The results have gratified both the department of English and the administrative officers of the college. No doubt we shall continue the course, with such variations as from time to time suggest themselves. The writer has watched intently the progress of the men who have had the course, particularly as these men have advanced through the sophomore, junior, and senior years.

The frequent correlation between poor work in English and poor work in other subjects is such as to indicate a limited aptitude in comprehension. Those to whom a grade of B was given at the end of the freshman course in 1934–35, maintained the same average in all their college work. And so we find it, year after year. Those who will find the going hard are likely to be placed in the lower percentiles in freshman English. More encouraging, however, is the fact that there are those in such groups who will undoubtedly succeed in all college work just as soon as they learn the fundamentals which such Remedial English provides.

The tangible results of such a course in Remedial English have been evident. In nearly every case the compositions show improvement in matters of accuracy and organization. The appalling ignorance concerning principles of grammar is considerably lessened, and students no longer depend upon what "looks right" or "sounds right." Vocabularies have been enlarged and spelling improved. Punctuation becomes a matter of logic and discretion rather than guess-work.

To remove such judgment of improvement from the biased opinion of the instructor, we have given the same Iowa training test at the end of the term and have compared scores with those made in September. In 1935–36, the total points of improvement for a class of twenty men reached 358. A chart of the scores would look like this:

Student	Spelling	Punct.	Grammar	Sentence Cat.	Spelling	Punct.	Grammar	Sentence
X	22	6	34	10	32	22	36	23
Y	18	33	21	13	30	23	24	14
Z	34	18	18	0	44	20	30	18

Similar results for the past year, 1936–37, indicate an improvement of 457 points. There were no failures at the end of the term. Students of the class took the regular freshman course in Argumentation during the second term and made good records. If a student fails the course in Grammar, he is required to take the Essay course in addition to the one in Argumentation. It is deemed wise to distinguish in this manner the training of the entering freshmen and see to it that the man who needs special training has the opportunity. Those who come well trained are placed where the subject matter is specialized over fields not generally covered in high school. We consider it desirable to omit the general composition course which is usually given to freshmen both in the Arts and Engineering colleges. As teachers in technical schools, ours is the problem of training for specific ends, namely, to give students of engineering a ready knowledge of accurate nomenclature and sentence construction; to present to them fundamentals in public speaking and logical processes in thought; and to offer advanced courses in literary appreciation including the novel, drama, poetry, and short story.

I am convinced that a course in Remedial English will not succeed unless the assignments and credits are equivalent to those of the other courses. In my judgment, it is wise to offer a course of this type on the college level rather than reject from entrance boys who have aptitude but insufficient training. There are many boys, moreover, who are well prepared in other subjects but have neglected English because they think it unimportant. For these a course in Remedial English serves two purposes; it gives them much needed training in the fundamentals and also convinces them of the importance of the English language to the professional engineer.

HERBERT R. YOUNG,
Associate Professor of English,
The Case School of Applied Science.

The T-SQUARE PAGE

DEVOTED TO THE INTERESTS OF THE DIVISION OF ENGINEERING DRAWING

FRED W. SLANTZ, EDITOR

TIMELY CRITICISM.

Our former Editor, Frederic G. Higbee, had this to say about grading of drawings: "Theoretically a drawing should be graded very much as a drawing is checked in commercial drafting rooms. However grading may be done, several elements are important: the marking should be objective and constructive; the student's work should not be ruined in the process of noting errors; and every error should be noted. How can this be done?"

Perhaps the emphasis should be placed more definitely on timely constructive *criticism* and less on *grading* of drawings.

In the commercial drafting room a drawing is either acceptable or it is not. It is checked and approved but it is not graded.

Regardless of how the grading of a drawing is done it misses its fullest educational value unless there is a definite provision for constructive personal criticism.

When and how is this criticism most effective? We believe that a personal inspection of each project is essential when it is well advanced but still susceptible of desirable alterations or additions. The initialing of a drawing by the instructor at this time should be understood to imply joint responsibility as to acceptibility, at least to that stage of the project. With this understanding, criticism is gratefully received by the student whether it be approval or the pointing out of faults to be corrected before final approval can be given.

Many an erring student will cheerfully redraw if given a pat on the back and a demonstration of how it should be done.

Teachers of engineering drawing have an exceptional opportunity to emulate the methods of instruction of the successful football coach.

Timely criticism is more effective than post mortems on the final score. The inculcation and development of critical ability in the student so that *he* can discriminate between various degrees of good form and practice, is perhaps more valuable to a future Engineer than the cultivation of drafting ability.

SECTIONS AND BRANCHES

The Fall Meeting of the **New England Section** of the Society for the Promotion of Engineering Education was held at Tufts College, Medford, Mass., on Saturday, October 9. The total registration was 284 members and guests.

From 10:00 A.M. until 12:00 M. four professional conferences were held. These were as follows:

Drawing—Attendance 26.
Chairman: E. F. Tozer, Northeastern University.
Subject: American Standard Drawings and Drafting Room Practice.
Speaker: E. H. Temple, Chairman, Standards Committee, Mechanical Drawing Association of New England.

Electrical Engineering—Attendance 53.
Chairman: W. B. Hall, Rhode Island State College.
Subject: Undergraduate Electrical Laboratory Courses.
Speakers: E. R. McKee, University of Vermont, E. L. Roberts, University of Maine.

Mathematics—Attendance 25.
Chairman: H. B. Phillips, M. I. T.
Subject: Mathematical Curricula.
Speakers: A. A. Bennett, Brown University, R. K. Morley, W. P. I., E. M. J. Pease, R. I. S. C., J. A. Bullard, University of Vermont.

Mechanics—Attendance 120.
Chairman: J. P. Den Hartog, Harvard University.
Subject: Soil Mechanics.
Speaker: Hardy Cross, Yale University.
Subject: Applied Mechanics in Industry.
Speaker: R. P. Kroon, Experimental Engineer, Westinghouse Electric and Manufacturing Company.

At a luncheon in the Cousens Gymnasium, President Compton of M. I. T., and Vice-President of the Society, brought greeting from President Earle and Secretary Bishop of the Society.

The Secretary read the minutes of the Burlington meeting and gave the financial report for the year ending October 30, 1936. Both the minutes and the financial report were approved.

Professor Kenerson of Brown, Chairman of the Nominating Committee, reported that the Nominating Committee, consisting of G. F. Eckhard, F. W. Garran, C. Frank Allen, W. S. Evans, and A. L. Townsend, did not care to make any recommendation limit-

ing the term of office of the chairman of the Section. They presented the names of S. W. Dudley for Chairman and C. E. Tucker for Secretary. The Chairman then put the names to vote and the nominees were elected for the ensuing year.

The General Session, held in Braker Hall, was called to order by the Chairman, Carl S. Ell of Northeastern University at 3:30 P.M. Dean Ell called on C. Frank Allen to introduce Arthur E. Morgan, Chairman of the Tennessee Valley Authority, who presented a paper on "The Engineer in an Expanding Government." Dean Frank W. Garran of Dartmouth introduced the Honorable George D. Aiken, Governor of Vermont, who spoke on "The Political Aspects of Flood Control in New England."

Immediately following the Annual Dinner the evening session was opened by Chairman Ell. The Secretary made several announcements after which Professor Dawes moved that the Society express a vote of appreciation for the good work of Chairman Ell in his leadership of the Section during the past three years. The motion was put to vote by Professor Allen and was unanimously carried. Chairman Ell then introduced William R. Leslie, of the St. Mark's Methodist Church, who spoke on "Recent European Adventures."

The Committee on Resolutions, consisting of Professors D. C. Jackson, C. H. Berry, and H. W. Melvin, then presented resolutions which were accepted by the Society.

The third annual meeting of the **North-Midwest Section** was held at Marquette University, November 12–13, 1937.

The following program was presented:

FRIDAY, NOVEMBER 12, 1937

4:00 P.M. Chairman: J. E. Schoen, Marquette University
Welcome: Dean F. A. Kartak, Marquette University
S. P. E. E. Convention Review: Ben G. Elliott, University of Wisconsin
NYA Programs: John H. Lasher, Wisconsin State Director, NYA

6:30 P.M. Dinner, Toastmaster: Dean F. A. Kartak
Address: Rev. Raphael C. McCarthy, S.J., President, Marquette University
Musical Selections: Variety Four
Address: R. I. de Garetz, de Garetz Laboratories, Milwaukee

8:30 P.M. Chairman: G. W. Swenson, Michigan College of Mining and Technology
"Engineering Research in Metals"—Samuel L. Hoyt, Director of Research, A. O. Smith Corporation

"What Does Industrial Research Expect of the University Trained Engineer"—Paul R. Croll, Director of Research, Paint and Varnish Division, Pittsburgh Plate Glass Co.

"Engineering Problems in the Development of the Internal Combustion Engines"—Charles W. Pendock, President, LeRoi Co.

"Cooperation between Educational Institutions and Industry in the Selection of Engineering Problems"—Arthur Simon, Consulting Engineer and Technical Advisor, Cutler-Hammer Mfg. Co.

DISCUSSION

SATURDAY, NOVEMBER 13, 1937

Group Conferences

Chemical Engineering—Chairman: O. L. Kowalke, University of Wisconsin

a) "Engineering Problems in the Milk Drying Industry"—L. G. Leutwiler, District Engineer, Pet Milk Company

b) "Chemical Engineering Aspects of the Tanning Industry"—A. C. Orthmann, Consulting Chemist, Orthmann Laboratories

c) "Technical Problems in a Paint and Battery Plant"—V. P. Lamm, Chief Chemist, Solar Corporation

d) "Problems in Distillation"—J. W. Lawrie, Director of Research, Jos. Schlitz Brew. Co.

Civil Engineering—Chairman: E. L. Waterman, University of Iowa

a) "Important Requirements for Young Engineers Entering Promotion and Sales Field"—W. D. M. Allen, Director of Promotion and Engineering Sales, Portland Cement Ass'n.

b) "Milwaukee Road Tracks and Tracks for High-Speed Light Weight Trains"—H. C. Christianson, Division Engineer, C. M. St. P. & P. Ry., LaCrosse, Wisconsin.

c) "Training of Engineers for Municipal Utilities and Research in Sewage Treatment"—J. L. Ferebee, Chief Engineer, Milwaukee Metropolitan Sewage Commission

d) "Planning Highway Beautification and Safety"—E. A. Howard, Regional Planning Engineer, Milwaukee

e) "Brief Report on 1937 Summer Conference of Surveying Instructors,"—J. S. Dodds, Prof. Civil Engineering, Iowa State College

Electrical Engineering—Chairman: H. R. Reed, Michigan College of M. and T.

a) "The Place of Electrical Controls in the Engineering Curriculum"—E. W. Seeger, Ass't. Chief Engineer, Cutler-Hammer Mfg. Co.

b) "Electrical Design in Industry and College"—L. H. Hill, Engineer in charge Transformer Development, Allis-Chalmers Mfg. Co.

c) "Use of Symmetrical Components in Electrical Utility Problems"—E. L. McClure, Ass't. System Engineer, T. M. E. R. & L. Co.

Mechanical Engineering—Chairman: M. P. Cleghorn, Iowa State College

a) "Problems Encountered in the Development of Marine Steam Turbines"—A. Hutton, A. M. I. N. A., Vice-President and General Manager, Taylor Mfg. Co.

b) "The Training of Engineers for the Power Plant Industry"—M. K. Drewry, Ass't. Chief Engineer of Power Plants, T. M. E. R. & L. Co.

c) "Engineers in the Paper Industry"—J. T. Whelan, Ass't. Chief Engineer, Kimberly-Clark Corporation, Neenah Wisconsin

d) "Machine Design in Heavy Machine Manufacturing"—W. P. Schmitter, Ass't. Chief Engineer, Falk Corporation

Metallurgical Engineering—Chairman: J. F. Oesterle, University of Wisconsin

a) "Newer Concepts of Welding"—J. C. Joublanc, Chief Metallurgist, Harnischfeger Corporation.

b) "The Development of Mining Equipment"—W. L. Maxson, Ass't. Chief Engineer, Mining Department, Allis-Chalmers Mfg. Co.

c) "Engineering Problems in a Malleable Foundry"—W. J. McNeil, General Manager, Federal Malleable Co.

d) "General Metallurgy in the Heavy Machine Industries"—Harold Stein, Chief Metallurgist, Allis-Chalmers Mfg. Co.

Mechanics—Chairman: M. O. Withey, University of Wisconsin

a) The Desirability and Effectiveness of the Use of Illustrative Mechanisms in Teaching Mechanics and Hydraulics
Leader: H. F. Gilkey, Iowa State College, Ames

b) To What Extent Should Students be Required to Follow a Systematic Form in Working Problems?
Leader: J. W. Howe, University of Iowa, Iowa City

c) What is the Desirable Number of Students in Mechanics Sections?
Leader: J. B. Kommers, The University of Wisconsin, Madison

d) How Can the Quantity and Quality of Outside Problem Work be Correctly Appraised and Its Originality Assured?
Leader: Glenn Murphy, Iowa State College, Ames

e) The Cultivation of Instinctive Perception of Principles by Simple Illustrations
Leader: R. J. Roark, The University of Wisconsin, Madison

f) Suggestions Regarding Means for More Closely Correlating the Teaching of Mechanics with Problems Involving Practical Application of the Principles
Leader: Member of Faculty of Michigan College of M. and T.

SATURDAY, NOVEMBER 13, 1937

11:00 A.M Chairman: F. A. Kartak, Marquette University
Annual business meeting and election of officers

12:00 NOON—1:15 P.M. Luncheon, Marquette Union

2:00 P.M. Football, Marquette University Stadium
Marquette *vs.* Iowa State.

COLLEGE NOTES

Armour Institute of Technology.—The Institute announces, as of October 11, the resignation of its President, Dr. Willard Eugene Hotchkiss. Dr. Hotchkiss assumed the presidency late in 1932. His administration has been marked by the growth of the Institute, both in number of faculty and students, and by the promotion of new educational services, including the Research Foundation, the Graduate Division, and the Cooperative Course in Mechanical Engineering. Dr. Hotchkiss leaves the Institute, with the respect and sincere good wishes of his colleagues, to the private practice of his profession as an economist.

Henry Townley Heald, Dean of the Institute since September, 1934, has been appointed Acting President by the Board of Trustees.

Linton E. Grinter, Ph.D., lately Professor of Civil Engineering at the Texas Agricultural and Mechanical College, has been appointed Professor of Civil Engineering, Director of the Civil Engineering course, and Dean of the Graduate Division. Dr. Grinter's training was at Kansas University and at the University of Illinois (Ph.D. 1928). His professional experience has been both academic and in the field. He is author of a two-volume text and reference book, "The Theory of Modern Steel Structures" (Macmillan), and has been unusually productive in research. He is a member of the American Society of Civil Engineering, and has been Chairman of the Civil Engineering Division, and of the Structural Committee, of the S. P. E. E.

Lester R. Ford, A.M. (Missouri), A.M. and Ph.D. (Harvard 1917), joined the staff in September as Professor of Mathematics and Head of the Department. Dr. Ford's experience includes a traveling fellowship in Paris, two years as Lecturer in Mathematics, University of Edinburgh, two years as Instructor at Harvard, and seventeen years as Assistant Professor of Mathematics at Rice Institute. He is author of numerous research papers and of a textbook of differential equations, has been a fellow of the Mathematics Research Council, is a member of the editorial board of the *American Journal of Mathematics,* and a former member of the Council of the American Mathematics Society.

Other staff appointments include:

William B. Ahern, B.S. (Armour 1935), Instructor in E. E.

Homer Carroll Combs, A.B. (Georgetown 1924), A.M., (Northwestern 1933), Instructor in English.

Paul L. Copeland, B.A. (Nebraska Wesleyan 1927), M.S. (Iowa 1930), Ph.D. (Iowa 1931), formerly on the faculty of M. I. T. and of Montana State College; Associate Professor of Physics, and Physicist in the Research Foundation; field of specialization, electronics.

Clayton O. Dohrenwend, C.E., M.C.E., M.S. (Rensselaer, 1931, 1935, 1937), Instructor in Civil Engineering; theory of elasticity, photoelasticity, and theory of structures.

Ernest Freireich, B.S., M.S. (Armour 1936, 1937), Instructor in Chemical Engineering.

William Hammer, student of Bonn, Cologne, and the Sorbonne, 1930–33, A.B., A.M., Ph.D. (Chicago, 1936, 1937), Instructor in French and German.

Robert Chester Kintner, B.Ch.E., M.S., Ph.D. (Ohio 1929), formerly assistant in Ch. E., Ohio State University; Assistant Professor, Rose Polytechnic Institute, Assistant Professor, Ohio State, and Assistant Professor, Bucknell University; with four years of industrial practice, Associate Professor of Chemical Engineering.

John Day Larkin, A.B. (Berea 1923), A.M. (Chicago 1923), Ph.D. (Harvard 1935), formerly instructor at Hamlein, Rutgers, North Dakota, and Harvard; lately, Assistant Professor of Political Science and Acting Head of the School of Business and Civic Administration, College of the City of New York, Associate Professor of Political Science.

Anna C. Orcutt, A.B. (Western Reserve 1925), A.M. (Western Reserve 1926), with wide experience in student personnel work, Instructor in Orientation, and Psychologist.

Irwin Earl Perlin, B.S., M.S. (Northwestern 1932, 1933); Ph.D. (Chicago, 1935), Formerly Assistant in Mathematics, Northwestern University, Instructor in Mathematics.

Carnegie Institute of Technology.—A gift of $300,000 was made by the Maurice and Laura Falk Foundation to the Carnegie Institute of Technology for the support of a program of education and research in social relations. In recognition of Mr. Maurice Falk's life-long interest in social problems, the Foundation will establish at Tech a professorship of social relations, and the holder of this position will have charge of the new educational program at Carnegie. At the suggestion of the Carnegie Institute of Technology, the chair will be known as a Maurice Falk Professorship of Social Relations.

The gift from the Falk Foundation will make it possible for Carnegie Tech to undertake two closely allied projects in its educational program, both of which are in keeping with the objectives of the Foundation in solving problems involving economic and social relationships.

The first of these projects will have as its objective the development in the young engineer of a social consciousness and social responsibility. To attain this end there will be set up at Tech a program of related social and cultural studies in the College of Engineering to run throughout the four-year college period of attendance.

The second project will provide for a continuing long range research study of the ever-changing social relationships in the industrial and business life.

Clemson College.—For the third consecutive year the enrollment of Clemson has exceeded all previous figures. There are 1,879 students on the campus this year. Of these 618 are in the School of Engineering and Architecture. In addition to the regular engineering students, textile, chemical and agricultural engineering majors take a considerable portion of their work in this school. Most other students, with the exception of Arts and Science majors, take at least one subject here.

Several changes have been made in the faculty and staff. J. A. Stevenson, Assistant Professor of Civil Engineering, is on special leave of absence in charge of instruction to surveyors on acreage control work for the Agricultural Adjustment Administration. His work is being taken by A. M. Quattlebaum. Professor Quattlebaum is a Civil Engineering graduate of Clemson, 1934, has a M.S. degree from Cornell University in Hydraulics and Structural Engineering and has worked for the South Carolina Highway Department, the T.V.A., and some private firms. M. S. Helm, Assistant Professor of Electrical Engineering, resigned to go into industry. H. E. Slone, Syracuse University, 1927, was appointed to fill the vacancy. He took the General Electric engineering course, following which he worked a number of years in the radio engineering department. Since that time he has been at Newport News in the employ of radio station WGH. S. W. Little, Assistant Professor of Architecture, resigned to take a similar position in the department of Architecture at Alabama Polytechnic Institute. Mr. T. K. Fitz Patrick has taken the position here. He holds both Bachelor's and Master's degrees in Architecture from Massachusetts Institute of Technology, where he has been an instructor since graduation in 1934. Mr. G. M. Carter, Graduate Assistant in Mechanical Engineering, accepted employment on the engineering staff of the Georgia Power Company, and his work has been taken by Mr. T. S. DuBose, Mechanical Engineering graduate of Clemson, 1934. Mr. J. S. Branch, Electrical Engineering, Clemson, 1936, has been added to the Mechanical Engineering staff as Instructor in Drawing and Shop.

At present three building projects for the college are under way. The College Y. M. C. A. is being remodeled to provide a doubled auditorium capacity. The Chemistry building is being added to, to provide more classroom and laboratory space. A new $465,000 textile building is in process of construction.

The college entertained the annual summer meeting of the South Carolina Society of Engineers in July, and is to be host at the annual meeting of the Southeastern Section of the S. P. E. E. the coming spring.

S. B. Earle, Dean of the School of Engineering, was elected president of the S. P. E. E. at the Boston meeting. He has also recently been elected a Manager of the American Society of Mechanical Engineers for a three year term.

University of Michigan.—Dean Herbert C. Sadler has resigned because of continued ill health and Professor Henry C. Anderson has been appointed Dean. Dean Anderson has been the Head of the Department of Mechanical Engineering since 1917.

J. E. Emswiler was made Chairman of the Department of Mechanical Engineering, to take the place of Professor H. C. Anderson.

J. A. Bolt was appointed instructor for the year to take the place of Assistant Professor H. L. Kohler on leave of absence. Mr. Bolt comes to the Department from the Chrysler Corporation.

H. L. Kohler is on leave of absence for the year developing a testing laboratory for the Sealed Power Piston Ring Company of Muskegon, Michigan.

R. S. Hawley is carrying on an extensive program in the investigation of various coal in Domestic Stokers.

E. S. Pettyjohn has returned to the University as Assistant Professor of Chemical Engineering.

Richard Schneidewind has been transferred from the Department of Engineering Research to a full-time position as Assistant Professor of Metallurgical Engineering.

Texas Technological College.—Ground has been broken for the construction of our new Library. It will be built in the Spanish renaissance style in keeping with other buildings on the campus, and will be a three story structure. We hope that it will be possible to have the new building ready for use by the opening of the fall semester, 1938.

This year we have had an increase in enrollment considerably above our expectations. In the Engineering Division we have had an increase of thirty-one percent over our enrollment for the fall semester, 1936–37.

Roger Clapp, Instructor in our Department of Mechanical Engineering who is on leave of absence for the year 1937–38, is doing graduate work at Purdue. Robert P. Vail, B.S. and M.S. in Mechanical Engineering, University of Minnesota, has assumed his duties for the current year.

Russell F. Redding, B.S. in Textile Engineering, Georgia School of Technology, who was formerly Assistant Professor in Textile Engineering, left us in June 1937 to accept a position on the technical staff of the Calloway Mills.

Cassius M. Stanley, B.S. in T.E., Alabama Polytechnic, 1933, has come as Assistant Professor of Textile Engineering. He was formerly associated with the Avondale Mills.

E. V. Middleton, B.S. in C.E., Texas Technological College, 1931, has been added to our staff in Civil Engineering. He was formerly employed by the Texas State Highway Department.

Willard F. Gray (B.S. in Electrical Engineering, 1934), has been appointed to the position of instructor in our Department of Electrical Engineering. Prior to his acceptance of this appointment, he was an employee of the Texas Power and Light Company.

BOOK REVIEWS

Utilization of Electrical Energy. E. Openshaw Taylor. D. Van Nostrand Co., Inc. 342 pages. $6.00.

Mr. Taylor has produced a book which will be very useful to general sales engineers, non-electrical students and certain men working in industry with the utilization of electrical energy. The chapter headings include, electric drive, electric traction. Heating and welding, electrolytic processes, illuminating engineering and economic aspects of utilizing electrical energy. The appendix contains regulations and specifications for factories, mines, I. E. E. wiring rules, etc.

Illustrative problems are included throughout the book in connection with the principles under discussion. Some fifty problems and questions are placed at the close of the six chapters, the answers to them being located at the end of the book.

This book should appeal to students, because throughout the text general principles have been stressed rather than details of construction. Quoting from the preface "The standard is approximately that of the London University B.Sc. (Eng.) Examination in Electrical Power (Utilization), but it also covers the requirements of other examinations such as the Installations section of the I. E. E. Graduateship examination in Electric Supply and installations."

R. C. Gorham.

Electrical Engineering, Vol. I, *Direct Currents.* Chester L. Dawes. McGraw-Hill Book Co. Third Edition. 751 pages. Price $4.50.

This book as well as the former two editions is devoted to the fundamental concepts and principles of direct current, and of their application to machinery.

Approximately 350 pages are devoted to the study of fundamentals of electricity. This study includes resistance, Ohm's law, Kirchoff's law, primary and secondary batteries, electrical instruments and measurements, permanent magnets, electromagnetism, magnetic circuits and flux measurements, inductance, electrostatics, and the measurement of capacitance. Brief footnote biographies are found at various intervals and should provide interest for the student. The author has used the calculus in development of certain relations. In addition to networks involving Ohm's and

Kirchoff's law, the author shows Delta and star systems of substitution.

Field intensity is developed for the cases, of a long wire, single turn coil and a long solenoid. Problems in magnetic circuits include the method of trial and error. The author discusses the properties of various magnetic alloys as well as giving a complete table showing properties of magnetic core materials. Transient currents for simple inductive and capacitance circuits are dealt with at some length. The author develops equations for the capacitance of parallel plates concentric spherical and cylindrical condensers. In passing, mention should be made of the excellent material on instruments and batteries.

The material dealing with generators, motors, losses, and distribution is given in the last six chapters and comprises 236 pages. In addition to studying generators and motors of standard performance, the author describes special generators, regulators, and automatic starters.

In addition to the reading material the book contains questions and problems dealing with the material in each chapter.

The book represents a growth from the previous edition rather than a change. While new material of a more advanced nature has been added, it undoubtedly is the answer to the demand for a better grounding of students in the fundamentals.

R. W. AHLQUIST.

ENGINEERING ENROLLMENTS, 1937–38

150 institutions giving instruction in engineering were requested to furnish the following information. 131 had replied as of December 7, 1937, 126 in the United States and 5 in Canada.

Engineering Courses	No. of Persons Teaching Course	Freshmen (1st year)	Sophomores (2nd year)	Juniors (3d year)	Seniors (4th year)	5th Year (of 5-yr. Curriculum)	Special Students	Evening Students	Others (Please name)	Totals	No. of First Degrees Conferred During the Academic Year 1936–37
Aeronautical		662	565	544	389	21	2	79	——	2,262	5
Agricultural		277	228	225	149	1	1	——	42	923	
Architectural		380	276	222	135	26	6	——	——	1,045	
Ceramic		158	166	97	68	——	63	——	——	552	
Chemical		3,457	3,529	2,764	2,097	155	18	465	17	12,556	11
Civil		2,085	2,476	2,096	1,930	101	24	500	14	9,226	10
Electrical		3,316	3,598	2,966	2,316	113	36	1,072	9	13,424	10
Industrial		444	619	532	450	39	2	96	——	2,184	
Mechanical		4,494	4,996	3,849	2,772	166	32	1,318	176	17,803	11
Metallurgical		461	546	374	274		3	218	1	1,877	2
Mining		452	404	329	237		7	——	1	1,430	2
Unclassified		9,003	1,092	341	29		130	3,593	312	14,531	
Others		1,759	1,337	969	839	2	12		1	4,915	
General		034	554	308	204		17		2	1,819	
Totals (131 Institutions)		27,713	20,646	15,618	11,887	624	353	7,341	575	84,547	*8,245
Totals 1936–37 (119 Institutions)		23,058	15,842	12,528	9,669	379	427	5,227	439	67,569	†7,881

* 103 Institutions reporting. † 103 Institutions reporting.

Summary of Undergraduate Enrollments in 131 Engineering Schools in 1937–38

126 Schools in United States

Engineering Courses	No. of Persons Teaching Course	Freshmen (1st year)	Sophomores (2nd year)	Juniors (3d year)	Seniors (4th year)	5th Year (of 5-yr. Curriculum)	Special Students	Evening Students	Others (Please name)	Totals	No. of First Degrees Conferred During the Academic Year 1936–37
Aeronautical	—	—	—	—	—	—	—	—	—	—	—
Agricultural	—	2	2	4	—	—	—	—	—	8	
Architectural	4	3	2	6	8	—	—	—	—	23	
Ceramic	1	6	2	2	—	—	—	—	—	11	
Chemical	68	69	95	75	—	—	—	—	—	307	
Civil	29	76	75	48	34	3	—	—	—	265	
Electrical	34	50	52	41	—	—	—	—	—	177	
Industrial	—	—	—	—	—	—	—	—	—	—	
Mechanical	52	30	55	61	—	—	—	—	—	198	
Metallurgical	17	33	26	24	—	—	—	—	—	100	
Mining	49	77	103	76	—	2	—	—	—	307	
Unclassified	660	261	—	—	—	—	—	—	—	861	
Others	22	21	12	8	—	—	—	—	—	63	
Totals	876	628	424	345	42	5	—	—	—	2,320	303

Undergraduate Enrollment by Institutions

Institution	Freshman (1st year)	Sophomore (2nd year)	Junior (3d year)	Senior (4th year)	5th Year (of 5-yr. Curriculum)	Special Students	Evening Students	Others	Total	No. of First Degrees Conferred in 1936–1937
Akron, U.	*63	*48	36	21	32	—	—	—	200	15
Ala. Poly.	245	227	183	184	—	13	—	—	852	91
Ala. U.	299	160	121	102	—	3	—	2	687	—
Ariz. U.	126	88	72	54	—	7	—	5	352	33
Ark. U.	132	85	61	40	—	—	—	—	318	26
Armour Inst.	298	235	144	153	—	27	1,995	168	3,020	160
Brooklyn Poly.	111	132	108	101	—	—	1,113	—	1,565	111
Brown U.	—	—	—	—	—	—	—	141	141	—
Bucknell U.	69	55	39	15	—	1	—	—	179	31
Calif. U.	323	248	434	365	—	—	—	—	1,370	195
Calif. Inst.	161	80	107	105	—	—	—	—	453	84
Calif. U. So.	67	69	86	66	—	3	—	—	291	52
Carnegie I. T.	331	322	219	181	—	6	1,010	—	2,069	192
Case School	281	251	182	135	—	—	648	18	1,515	123
Catholic U.	56	29	17	17	—	—	—	—	119	30
Cincinnati U.	408	371	257	157	112	—	226	—	1,531	82
Citadel	*50	48	32	26	—	—	—	—	156	22
Clarkson Coll.	131	91	77	57	—	—	—	—	356	56
Clemson Coll.	299	183	100	94	—	—	—	—	676	42
Colo. Mines	251	203	150	99	—	—	—	—	703	76
Colo. Ag. Coll.	225		56	41	—	—	—	—	322	—
Colo. U.	277	217	144	115	—	—	—	—	753	107
Columbia U.	58	53	—	—	—	—	—	—	111	62

Undergraduate Enrollment by Institutions—Continued

Institution	Freshman (1st year)	Sophomore (2nd year)	Junior (3d year)	Senior (4th year)	5th Year (of 5-yr. Curriculum)	Special Students	Evening Students	Others	Total	No. of First Degrees Conferred in 1936–1937
Columbia Coll.	110	97	98	——	——	——	——	——	305	——
Conn. Coll.	48	22	9	13	——	——	——	——	92	6
Cooper Union (Day)	103	95	65	58	——	——	——	——	321	47
Cooper Union (Evening)	207	206	162	137	68	——	——	——	809	12
Cornell U.	350	282	187	175	14	——	——	——	1,008	145
Dartmouth Coll.	*20	*20	*20	14	5	1	——	——	80	14
Dayton U.	93	57	32	21	——	——	——	——	203	16
Dela. U.	69	52	35	20	——	2	——	——	178	23
Denver U.	76	77	33	37	——	1	——	——	224	——
Detroit U.	233	126	134	67	44	——	——	1	605	39
Drexel Inst.	315	207	127	103	80	4	——	——	836	78
Duke U.	64	49	28	21	——	——	——	——	162	30
Florida U.	——	5	104	101	——	1	——	——	211	39
Ga. Sch. Tech.	708	533	446	271	——	——	——	——	1,958	——
Geo. Wash. U.	141	74	79	46	——	——	——	——	340	43
Gettysburg Coll.	28	12	7	6	——	——	——	——	53	——
Hawaii U.	41	15	10	12	——	——	——	——	78	5
Howard U.	21	8	1	6	——	——	——	——	36	1

* Estimated.

* Estimated.

Undergraduate Enrollment by Institutions—Continued

Institution	Freshman (1st year)	Sophomore (2nd year)	Junior (3d year)	Senior (4th year)	5th Year (of 5-yr. Curriculum)	Special Students	Evening Students	Others	Total	No. of First Degrees Conferred in 1936–1937
Idaho U.	136	194	126	60	—	3	—	—	519	47
Illinois U.	940	553	474	351	—	—	—	*60	2,378	285
Iowa St. Coll.	651	412	294	203	—	9	—	—	1,569	163
Iowa U.	131	106	80	74	—	6	—	8	405	—
Johns Hopkins U.	94	101	65	47	—	1	—	—	308	57
Kansas Coll.	379	236	220	171	—	1	—	—	1,007	126
Kansas U.	181	168	141	133	—	3	—	42	668	90
Kentucky U.	125	132	90	55	—	1	—	—	403	60
Lafayette Coll.	98	61	63	35	—	—	—	—	257	33
Lewis Inst.	71	50	40	45	—	19	*160 †650	—	1,035	—
Louisiana U.	—	203	152	99	—	4	—	—	458	74
Louisville U.	60	39	35	31	—	—	—	3	168	22
Maine U.	164	120	65	78	—	16	—	2	445	61
Manhattan Coll.	85	61	43	28	—	—	—	—	217	—
Marquette U.	169	122	102	70	69	9	—	—	541	55
Maryland U.	163	93	51	42	—	—	—	4	353	42
Mass. Inst. Tech.	528	511	481	392	—	—	—	—	1,912	321
Mich. Mines	223	188	132	121	—	—	—	15	679	72

† Special Evening Students.

Undergraduate Enrollment by Institutions—Continued

Institution	Freshman (1st year)	Sophomore (2nd year)	Junior (3d year)	Senior (4th year)	5th Year (of 5-yr. Curriculum)	Special Students	Evening Students	Others	Total	No. of First Degrees Conferred in 1936–1937
Mich. Coll.	284	224	139	107	—	—	—	—	754	93
Mich. U.	418	462	540	431	—	7	—	—	1,858	324
Minn. U.	585	558	428	290	—	—	—	—	1,861	188
Missouri U.	199	130	95	56	—	—	—	—	480	44
Missouri Mines	228	157	144	100	—	—	—	—	629	—
Montana Coll.	159	124	56	53	—	—	—	—	392	47
Montana Mines	127	90	45	29	—	3	—	—	294	28
Miss. Coll.	277	248	155	124	—	—	—	—	804	—
Miss. U.	21	22	10	8	—	—	—	—	61	5
Nebraska U.	304	182	146	101	—	—	—	—	733	59
Nevada U.	123	60	27	17	—	2	—	—	229	—
Newark Coll.	205	159	148	93	—	14	154	—	773	137
N. Hamp. U.	146	99	70	58	—	2	—	—	375	51
N. Mex. U.	87	43	27	14	—	—	—	—	171	14
N. Mex. A. M.	*97	32	31	23	—	1	—	7	191	—
N. Mex. Mines	74	35	28	26	—	4	—	—	167	18
New York U.	227	202	162	133	—	72	1,184	—	1,980	217
No. Car. Coll.	399	279	142	108	—	—	—	—	928	117
No. Dak. Coll.	158	81	68	48	—	—	—	—	355	—
No. Dak. U.	109	68	34	38	—	63	—	—	312	30
No. East. U.	*375	*306	*170	*174	155	—	—	—	1,180	223
No. West. U.	98	79	36	43	—	—	—	—	256	—
Norwich U.	51	28	16	19	—	—	—	—	114	15
Notre Dame	181	110	82	63	—	—	—	—	436	51

Undergraduate Enrollment by Institutions—Continued

Institution	Freshman (1st year)	Sophomore (2nd year)	Junior (3d year)	Senior (4th year)	5th Year (of 5-yr. Curriculum)	Special Students	Evening Students	Others	Total	No. of First Degrees Conferred in 1936–1937
Ohio St. U.	656	633	394	304	16	—	—	—	2,003	185
Okla. A. M.	369	250	218	161	9	1	—	—	1,008	89
Okla. U.	455	355	388	218	—	—	—	—	1,416	—
Oregon Coll.	286	271	158	126	—	—	—	—	841	71
Penna S. Coll.	510	444	351	227*	—	—	—	—	1,532	188
Penna. U.:										
Towne Sci.	103	83	65	56	—	—	—	—	307	65
Moore E. E.	27	23	18	13	—	—	—	—	81	16
Pittsburgh U.	256	182	155	173	—	11	201	71	1,049	126
Princeton U.	106	80	59	49	—	—	—	—	294	39
Purdue U.	1,261	994	727	446	—	5	—	—	3,433	399
Rensselaer Poly.	409	299	191	229	—	2	—	—	1,130	172
Rhode Isl. Coll.	93	73	63	51	—	—	—	—	280	39
Rice Inst.	181	122	81	46	—	—	—	—	430	45
Rose Poly.	103	47	32	36	—	—	—	—	218	26
Rochester U.	66	39	36	17	—	—	—	—	158	18
Rutgers U.	88	45	48	27	—	7	—	—	215	—
Santa Clara U.	38	23	17	9	—	—	—	—	87	11
S. Dak. Coll.	95	64	38	25	—	—	—	—	222	37
S. Dak. Mines	122	91	64	41	—	—	—	—	318	42
So. Meth. U.	88	38	19	14	13	—	—	—	172	11
Stanford U.	104	*118	52	82	—	—	—	—	356	67

Undergraduate Enrollment by Institutions—Continued

Institution	Freshman (1st year)	Sophomore (2nd year)	Junior (3d year)	Senior (4th year)	5th Year (of 5-yr. Curriculum)	Special Students	Evening Students	Others	Total	No. of First Degrees Conferred in 1936–1937
Stevens Inst.	179	154	99	93	—	—	—	—	525	101
Swarthmore Coll.	20	20	13	12	—	—	—	—	65	15
Syracuse U.	150	129	75	61	—	—	—	—	415	—
Tennessee U.	256	145	73	54	7	—	—	—	535	—
Texas A. M.	1,165	619	381	247	—	5	—	—	2,417	173
Texas U.	625	363	288	218	—	—	—	—	1,494	120
Texas Tech.	393	154	104	87	—	—	—	—	738	56
Toledo U.	143	71	46	34	—	—	—	—	294	—
Tufts Coll.	121	106	80	59	—	—	—	—	366	81
Tulane U.	112	69	53	51	—	1	—	—	286	38
Union Coll.	78	56	35	31	—	—	—	—	200	30
Utah U.	231	116	66	51	—	—	—	—	464	—
Valparaiso U.	39	22	6	9	—	—	—	—	76	—
Vanderbilt U.	*61	56	40	28	—	—	—	—	185	—
Vermont U.	45	32	19	17	—	—	—	—	113	18
Va. Mil. Inst.	—	—	84	63	—	—	—	—	147	34
Va. Poly.	558	342	215	180	—	—	—	—	1,295	170
Virginia U.	87	49	52	20	—	1	—	—	209	23
Wash. U. (St. Louis)	128	99	90	43	—	9	—	—	369	—
Washington U.	761	291	233	218	—	—	—	—	1,503	145
Washington Coll.	179	123	81	80	—	—	—	—	463	43

Washington Coll.	179	123	81	80	—	—	—	—	463	43

Undergraduate Enrollment by Institutions—Continued

Institution	Fresh-man (1st year)	Sopho-more (2nd year)	Junior (3d year)	Senior (4th year)	5th Year (of 5-yr. Curricu-lum)	Special Students	Evening Students	Others	Total	No. of First Degrees Conferred in 1936–1937
W. Virginia U.	170	119	98	64	—	—	—	—	451	49
Wisconsin U.	437	443	284	211	—	—	—	—	1,375	121
Worcester Poly.	214	162	132	77	—	—	—	—	685	82
Wyoming U.	135	78	66	45	—	2	—	—	326	—
Yale U.	—	84	76	57	—	—	—	—	217	49
United States	27,532	20,326	15,536	11,824	625	353	7,341	575	84,111	8,194
CANADIAN										
Alberta U.	89	65	60	36	—	—	—	—	270	—
Ecole Poly.	120	54	36	27	34	3	—	—	274	40
Queen's U.	208	191	123	98	—		—	—	622	103
Sask. U.	183	91	42	36	—	—	—	—	352	29
Toronto U.	276	227	173	148	8	—	—	—	832	131
Canadian	876	628	424	345	42	5	—	—	2,320	303
United States	27,713	20,646	15,618	11,887	625	353	7,341	575	84,547	8,245
Grand Total	28,589	21,274	16,042	12,232	667	358	7,341	575	86,867	8,548
Received too late to classify:										
Lehigh U.	360	347	231	168	—	4	—	—	1,110	132

Enrollment of Graduate Engineering Students, 1937–38

Institutions	Enrollment in Work for the Master's Degree						Enrollment in Work for the Doctor's Degree					
	Full-Time Resident Students	Part-Time Resident Students	Evening Students	Others (Please name)	Total	Masters Degrees Conferred in 1935–36	Full-Time Resident Students	Part-Time Resident Students	Evening Students	Others (Please name)	Total	Doctors Degrees Conferred in 1935–36
A. P. I.	6	—	—	—	6	6	—	—	—	—	—	—
Ala. U.	1	—	—	—	1	1	—	—	—	—	—	—
Ariz.	12	6	—	—	18	7	—	—	—	—	—	—
Ark.	—	—	—	—	1	1	—	—	—	—	—	—
Armour	1	15	193	—	209	4	1	—	—	—	1	—
Brooklyn	—	8	275	—	283	21	—	—	9	9	18	2
Brown	—	—	—	—	2	—	—	—	—	—	—	—
Bucknell	2	—	—	—	2	1	—	—	—	—	—	—
Cal. I. T.	93	—	—	—	93	66	22	—	—	—	22	5
Cal. U. So.	1	9	—	—	10	5	—	—	—	—	—	—
Cal. U.	50	35	—	—	85	35	1	—	—	—	1	—
Carnegie	15	—	91	—	106	11	6	—	—	—	6	—
Case	2	29	22	—	53	18	—	2	—	—	2	—
Cin.	1	—	—	—	1	1	—	—	—	—	—	—
Colo. Mines	9	—	—	—	9	4	—	—	—	—	—	—
Colo. U.	—	—	—	—	—	6	—	—	—	—	—	—
Cornell	57	—	—	5	62	30	12	—	—	—	12	7
Columbia	23	38		43	104	27 *36	5	39	—	—	44	13
Florida	2	—	—	—	2	—	—	—	—	—	—	—

* Eng. Degree.

* Eng. Degree.

Enrollment of Graduate Engineering Students, 1937–38—Continued

Institutions	Enrollment in Work for the Master's Degree						Enrollment in Work for the Doctor's Degree					
	Full-Time Resident Students	Part-Time Resident Students	Evening Students	Others (Please name)	Total	Masters Degrees Conferred in 1935–36	Full-Time Resident Students	Part-Time Resident Students	Evening Students	Others (Please name)	Total	Doctors Degrees Conferred in 1935–36
Ga. Tech	——	17	——	——	17	3	——	——	——	——	——	——
Harvard	63	15	0	——	78	70	10	13	0	——	23	7
Idaho	11	——	——	——	11	9	——	——	——	——	——	——
Illinois	24	44	——	——	68	52	11	26	——	——	37	15
Iowa Coll	12	15	——	8	35	22	——	12	——	1	13	2
Iowa U	23	——	23	——	46	7	6	——	——	——	6	3
Johns H	4	4	——	——	8	4	11	1	——	——	12	5
Kans. U	3	1	——	——	4	2	——	——	——	——	——	——
Kans. St	1	7	——	——	8	5	——	——	——	——	——	——
Ky	——	4	——	——	4	7	——	——	——	——	——	——
Lafayette	——	——	——	——	——	1	——	——	——	——	——	——
Lehigh	8	28	0	0	36	15	2	11	0	0	13	0
La. St. U	——	——	——	——	52	10	1	——	——	——	——	——
Louisville	5	——	15	——	20	2	——	——	——	——	——	——
Maine	1	3	0	——	4	5	——	——	——	——	——	——
Manhattan	4	13	——	——	17	——	——	——	——	——	——	——

Enrollment of Graduate Engineering Students, 1937–38—Continued

Institutions	Enrollment in Work for the Master's Degree						Enrollment in Work for the Doctor's Degree					
	Full-Time Resident Students	Part-Time Resident Students	Evening Students	Others (Please name)	Total	Masters Degrees Conferred in 1935–36	Full-Time Resident Students	Part-Time Resident Students	Evening Students	Others (Please name)	Total	Doctors Degrees Conferred in 1935–36
M. I. T.	318	—	—	—	318	183	108	—	—	—	108	23
Mich. U.	108	*2	6	—	*2	*4	*3	*3	*1	—	*7	22
		17			131	130	12	26	—		38	
Mich. Coll.	—	7	—	—	7	2	—	—	—	—	—	—
Mich. Mines	3	—	—	—	3	—	—	—	—	—	—	—
Mo. U.	1	—	—	—	1	1	—	—	—	—	—	—
Mo. Mines	6	—	—	—	6	—	5	—	—	—	5	—
Mont. Mines	12	—	—	—	12	10	—	—	—	—	—	—
Mont. Coll.	—	2	—	—	2	0	—	—	—	—	—	—
Moore E. E.	4	—	39	—	43	2	2	—	—	—	2	1
Nebr.	3	—	—	—	3	2	—	—	—	3	3	3
N. H.	—	1	—	—	1	4	—	—	—	—	—	—
N. Y. U.	13	80	75	—	168	14	—	5	1	—	6	—
No. C. St.	2	11	—	—	13	4	—	1	—	—	1	—
No. D. U.	1	1	—	—	2	1	—	—	—	—	—	—
Ohio St. U.	31	15	—	—	46	24	12	10	—	—	22	4
Okla. A. & M.	7	—	—	—	7	5	—	—	—	—	—	—
Okla. U.	3	—	—	—	3	2	—	—	—	—	—	—
Ore.	1	3	—	—	4	3	—	—	—	—	—	—

* Professional Degree.

Professional Degree.

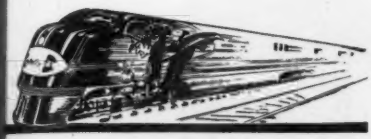
Enrollment of Graduate Engineering Students, 1937–38—Continued

Institutions	Enrollment in Work for the Master's Degree						Enrollment in Work for the Doctor's Degree					
	Full-Time Resident Students	Part-Time Resident Students	Evening Students	Others (Please name)	Total	Masters Degrees Conferred in 1935–36	Full-Time Resident Students	Part-Time Resident Students	Evening Students	Others (Please name)	Total	Doctors Degrees Conferred in 1935–36
Pa. St.	6	13	—	7	26	15	3	2	—	5	10	2
Pa. U. Town	—	—	—	—	44	—	—	—	—	—	—	—
Pittsburgh	—	121	—	—	121	0	9	—	—	—	9	—
Princeton	10	—	—	—	10	10	—	—	—	—	—	—
Purdue	21	27	—	—	48	20	1	12	—	—	13	0
R. P. I.	6	—	—	—	6	13	1	—	—	—	1	5
Rochester	2	5	—	—	7	1	—	—	—	—	—	—
Rutgers	1	7	—	—	8	0	—	—	—	—	—	—
So. D. Coll.	—	2	—	—	2	1	—	—	—	—	—	—
So. D. Mines	1	2	—	—	3	2	—	—	—	—	—	—
Stevens	6	16	19	1	42	5	—	—	—	—	—	—
Swarthmore	—	1	—	—	1	0	—	—	—	—	—	—
Syracuse	3	—	—	—	3	0	—	—	—	—	—	—
Stanford	63	—	—	—	63	22	7	—	—	—	7	2
Tenn.	—	11	25	50	86	0	—	—	—	—	—	—
Tex. A. M.	11	17	—	—	28	15	—	2	—	—	2	—
Tex. Tech	1	—	—	—	1	0	—	—	—	—	—	—
Tex. U.	16	14	—	—	30	13	0	4	—	—	4	4
Toledo	—	—	25	—	25	0	—	—	—	—	—	—
Tulane	—	7	—	—	7	1	—	—	—	—	—	—

Enrollment of Graduate Engineering Students, 1937–38—Continued

Institutions	Enrollment in Work for the Master's Degree						Enrollment in Work for the Doctor's Degree					
	Full-Time Resident Students	Part-Time Resident Students	Evening Students	Others (Please name)	Total	Masters Degrees Conferred in 1935–36	Full-Time Resident Students	Part-Time Resident Students	Evening Students	Others (Please name)	Total	Doctors Degrees Conferred in 1935–36
Vermont	0	0	0	0	0	1	—	—	—	—	—	—
Va. P. I.	34	5	—	—	39	31	—	—	—	—	—	—
Va. U.	—	—	—	—	2	2	—	—	—	—	—	—
Wash. U.	13	17	—	—	30	8	—	5	—	—	5	—
W. Va. U.	—	2	—	—	2	2	—	—	—	—	—	—
Wis.	34	—	—	—	34	0	—	—	—	—	—	—
W. P. I.	2	—	—	4	6	5	—	—	—	—	—	—
Yale	19	2	—	3	24	7	14	4	—	—	18	1
	1,202	692	808	222	2,924	1,058	265	178	11	18	472	126
CANADIAN												
Queens	6	—	—	—	6	—	—	—	—	—	—	—
Sask.	6	—	—	—	6	3	—	—	—	—	—	—
Toronto	11	—	—	—	11	11	4	—	—	—	4	1
Grand Total	1,225	692	808	222	2,947	1 072	269	178	11	18	476	127

G-E *Campus News*



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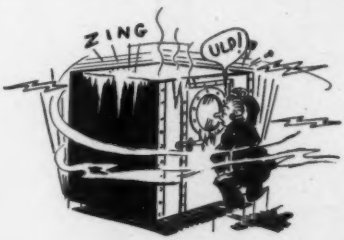

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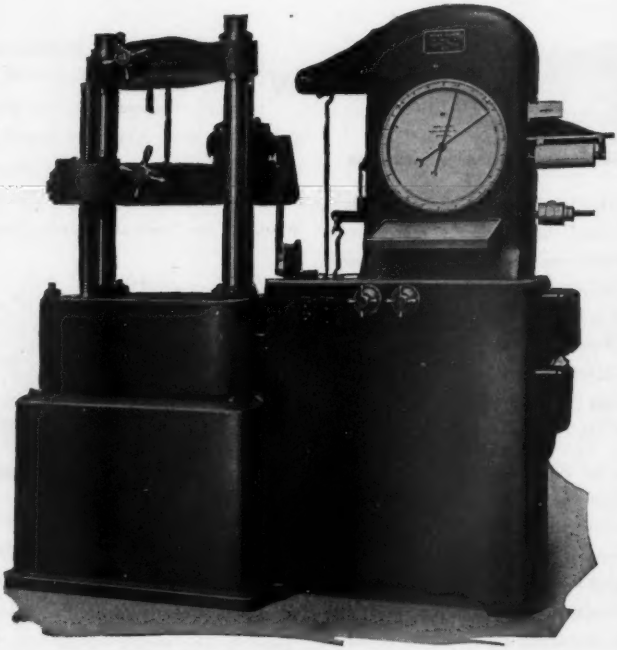

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